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ARTHUR BLISS SEYMOUR

1859–1933

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(WITH PORTRAIT)

The thinning ranks of the older school mycologists in America met another sad loss in the death of Arthur Bliss Seymour, March 29, 1933. This date lacks but a year of the full century following the death of de Schweinitz, American pioneer in this field. Seymour's work fully bridged the last half of this formative period in American mycology. Before, however, reviewing Seymour's

[1] The author is indebted to Professor Seymour's family for information obtained from correspondence, notes, etc., as to the ancestral and personal history. The bibliography is due especially to the daughter, Edith Seymour Jones.

In order to avoid, so far as might be, error concerning scientific facts and institutional relations involved, Professors William Trelease, J. J. Davis and W. H. Weston, each has kindly aided by a critical reading, with some minor revisions of the manuscript. Professor Trelease also invited attention to a contribution by Professor Seymour of definite and lasting significance which, as he suggests, well illustrates Seymour's peculiar genius for painstaking methods with meticulous attention to detail. At the Madison Botanical Congress of 1893 Seymour was member with Barnes and Britton of the committee on botanical bibliography and typography. Upon request Seymour prepared a report on the principles and rules which should govern citations to literature. This was adopted by the Congress and later by the Botany section of A. A. A. S. (see references in the bibliography). As a result "the Seymour rules of citation," in their essentials, have since continued to dominate the usage of most American botanical publications and have indirectly influenced bibliographical citations generally.

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part in this half century's progress, it will be well to recall his unusual character and personality, and somewhat of that which contributed to these. The first American ancestor of his line, Richard Seymour, migrated from Hertfordshire, England, to Hartford, Connecticut, in 1639. Six generations of Seymours remained in Connecticut and Massachusetts until his own father went in 1853 from Granville, Massachusetts, to join other pioneers in Moline, Illinois. His maternal line came of similar New England stock. His mother, Mary Bliss, was, however, born in Hawaii, where her parents had gone as missionaries in 1837. Her father, upon returning, was pastor of the first church in Moline. Thus Seymour was of Puritan ancestry, "families of ministers and missionaries." Orphaned in early childhood, his boyhood upbringing by elderly great aunts and uncles fixed the inbred devotion to religious idealism and the direct values of the simple life. When that which is of best worth is clearly visioned one's course is fixed; it remains only to carry through as he did to the very end. Young Seymour was naturally a merry child, especially responsive to friendly companionships. It was the more unfortunate, therefore, that partial deafness resulted from scarlet fever before he was five years old. The consequent limitation in personal relations accentuated a natural tendency to shyness and introspection. These conditions doubtless contributed materially to his carefully considered devotion through life to a few major interests. His botanical studies were from their beginnings most inspiring and most exacting of time and energy. But they were to him an integral part of a life dedicated to what was conceived as his best worthwhile services to his kind. The spirit was the same whether expressed in devotion to family, to missions [2] or to mycology. Home and family responsibilities were at once his solace and concern throughout the half century of his professional life. Married in 1886, the parents left four children. In addition to the attendant home responsibilities Mrs. Seymour was a sympathetic co-worker in all his scientific undertaking until her death one year before his own. The first such service to mycology

[2] For more than twenty years he was teacher of a group of men in a Chinese Sunday School in Boston and in his later life a member of the Advisory Council of Yenching University, Peiping, China.

was in proof-reading the Farlow-Seymour Host Index, 1888–1889. The last, forty years later, was the far greater one of proof-reading the seven hundred exacting pages of the Seymour Host Index of 1929.

The instincts of the naturalist directed his boyhood bent to the plant life about him. Nothing could be more enticing, surrounded as he was by the lushest of varied floras where the Illinois prairies met the bottom lands of the Mississippi River. He early learned to identify the simpler plants from happy associations with a neighboring amateur botanist. His botanical interests in turn stimulated him to supplement his regular schooling by special work with Latin. And again this same interest in plants decided his choice of college. He might have entered Knox, near-by, but instead he turned in 1878 to Illinois University that he might be with Burrill. He took with him to Burrill's laboratory a herbarium of some 500 plants and his major interests continued in botany. The collegiate courses in this were limited so he soon completed these and became Burrill's assistant and tutor to the less apt.

From young Seymour's first contacts with Burrill the character and influence of this teacher continued a dominant influence in his life. Evidently this was true of many Illinois students during those two formative decades in economic botany, the seventies and eighties. Probably no other period in Burrill's half century at Illinois was more significant and stimulating than the six eventful years, 1877–1883, when Seymour was there. Burrill then initiated and completed his epochal demonstration that pear blight is caused by parasitic bacteria. He thus solved the riddle of a century in American horticulture and made one of the outstanding contributions to world progress in the field of plant pathology. Being a man of great energy and in life's prime, Burrill was at the same time pushing other important projects. His own teacher of botany, Sewall, being Curator of the State Museum of Natural History, Burrill had early become an enthusiastic leader in the botanical explorations of the Illinois Natural History Survey. Combining as he did responsibilities for leadership in horticulture with botany, and sensing the rapid increase in recognition of the importance of parasitic disease of plants as well as animals, he turned especial attention to the parasitic fungi of Illinois. As a result he

conceived of specialized surveys for these. From the outset, as Barrett [3] points out, Burrill happily associated his students with him in these natural history surveys extending " from Chicago to Cairo." Thus even as an undergraduate Seymour's early enthusiasm as a botanical explorer received constant stimulation from association with his veteran naturalist teacher.

Seymour's notes record that in the summer of 1879 he was commissioned to work over and systematize the valuable State Survey collections which had been accumulating in the University herbarium. The next summer while engaged in further field exploration, with increasing interest in the parasitic fungi, he first met F. S. Earle. This marks the beginning of their long and mutually stimulating associations in mycological work. Before graduation in 1881 Burrill assured Seymour of full time appointment on the staff of the Natural History Survey with opportunity to devote his time wholly to this fascinating work. He notes that " for nearly two years . . . I scoured the state with a hand lens as thoroughly as I could from Jo Daviess and McHenry to Union and Jackson Counties . . . " adding that when winter closed the field collecting, work turned to the compound microscope in the laboratory upon the fungi which he had collected, Burrill giving such aid as he could, and F. S. Earle coöperating. " Our leading topics at that time were the rusts and the powdery mildews," Seymour giving first attention to the rusts and Earle to the mildews. Thus the foundations were laid for the two monographs on the parasitic fungi of Illinois.[4] Doubtless had Seymour remained longer at Illinois he would have had the personal satisfaction and credit of joint authorship with Burrill on the Uredineae as had Earle on the Erysipheae. As it was, when Part I, dealing with the rusts, appeared in 1885 Burrill states in the Introduction, " most of the plants herein described were collected in Illinois in 1881 and 1882 by Mr. A. B. Seymour. The entire collection consisted of three

[3] Barrett, T. J., Thomas Jonathan Burrill. Phytopath. **8**: 2. 1918.

[4] Parasitic fungi of Illinois. Part I (Uredineae). T. J. Burrill. 1885. Part II (Erysipheae). T. J. Burrill and F. S. Earle. 1887. G. P. Clinton later continued in Burrill's laboratory this work upon the parasitic fungi, giving special attention to the smuts. His studies, completed in Farlow's laboratory, resulted in his monographs on American smuts. (See Seymour's note concerning this cited in the bibliography.)

thousand, seven hundred and eighty-four numbers, many of which are of course duplicated, or are different stages of the same species, leaving, however, a large number of distinct specific forms, much larger than is usually supposed to exist in our flora." Burrill, in the publication cited above, acknowledges also the efficient aid of Seymour in species determinations of the rusts aided by the facilities of the libraries and herbaria of the University and State Laboratory. In using these, Seymour records his early recognition of the need of indexes and the beginnings made with the card system in his student days. The usefulness of this card index was such that it grew rapidly during the winters concentrated upon mycological studies 1881–1883. This was to be of greater portent than at first conceived. As Seymour's notes record it, "in the spring of 1883 Professor W. G. Farlow, of whom I had been seeking some technical information, asked me to go to Cambridge as his assistant, temporarily. Burrill advised me to go. The need of a better library had been keenly felt by both of us, as had also facilities for using it. Cambridge had a smaller index of similar kind and greater facilities for extending it. It offered also greater opportunities for studying the plants themselves and that was what I wanted most. . . ." "Our purpose in Illinois was to know Illinois fungi. Dr. Farlow's purpose was to construct a monograph of North American Fungi."

The next year was spent busily and happily on the Harvard mycological indexes. This period, 1883–1884, marks the real beginning of his life work upon these indexes, but the permanent undertaking was destined to be delayed for three years by a series of distracting but eventful and profitable opportunities such as alert, venturesome young college graduates always welcome. The first of these was a return in 1884 for summer field work in mycology with Burrill and Earle, continuing the Illinois mycological surveys. The second immediately following in the autumn of '84 was a collecting trip over the Northern Pacific railroad to the Columbia River basin. Professor Forbes, as Director of the Illinois State Laboratory, had asked him to return the next summer for permanent appointment on the state staff. He would have so done but for the linkage of two other opportunities. In December '84 Dr. Farlow, wishing to join Dr. Gray on a winter's sojourn on

the Pacific coast, invited Seymour again to care for the herbarium and indexing during his absence. Immediately following, 1885–1886, he was called to the University of Wisconsin for a year. Professor William Trelease had, in 1881, gone there from Farlow's laboratory where he, just preceding Seymour, had also worked upon the Harvard Indexes. In 1885 Trelease transferred to St. Louis for the combined responsibilities at Washington University and the Missouri Botanical Garden. This led to the emergency opportunity for young Seymour to try his hand at teaching general botany at Wisconsin during the interim between the Professorships of Trelease and Barnes. He was urged to remain but although he recognized it as a stimulating and broadening experience, his natural genius, probably influenced by his handicap in hearing, confirmed his preference for specialized work in mycology rather than what he records as " the burdensome routine of teaching general botany." So he welcomed the opportunity which came in the autumn of '86 to accept Dr. Farlow's proffer of permanent appointment on the staff of the cryptogamic herbarium. This was the more opportune because in May of that year he had returned to Illinois for his marriage, and in June for his M.S. degree.

He was now adequately matured and trained for his special life work in mycology. The Harvard Indexes were to dominate the rest of his life. Before discussing these, however, some of the side interests, especially of the next decade, deserve reference. These serve to illustrate two life-long characteristics, his devotion in service to family and fellowmen and his naturalist's eagerness for the out-of-doors. The first specific side-service was suggested by the rapidly increasing attention to plant pathology consequent upon the organization of work in this field in the various state and federal institutions. Renewing his early Illinois associations with F. S. Earle, the two issued the eight fascicles of Economic Fungi (1890–1893) with later supplements; G. P. Clinton editing the Ustilagineae, which closed the series in 1905. The second side line came from his desire to have his children associated in nature study and consisted in supplying highly reliable botanical specimens and associated services to many colleges and schools. The children became eager and trained collectors and preparateurs and shared the joys of the naturalist with the satisfactions of small

material additions whether to the family educational funds or the budgets of foreign missions. Still a third undertaking, again combining his enthusiasm for the field with that for timely service, resulted in a summer school at Cambridge dealing with mycology, especially the parasitic fungi. The writer attended this in 1890 as one of an eager group of young college graduates. Professor Seymour proved an able lecturer, his talks characteristically enriched by blue-print outlines or synopses. The laboratory work dealt especially with systematic mycology. He was at his best in the field as an eager leader in assembling surprisingly rich collections of parasitic fungi, of which he knew both habitat and host relations over a wide area. At about this time also he was lecturing in botany in Radcliffe College. But it was no more his intent than that of Dr. Farlow to permit any such side lines to distract unduly from the dominant interest of both alike, the mycological indexes.

Seymour's work on the Harvard Mycological Indexes, begun as noted in 1883, continued from its resumption in 1886 without interruption until his last weeks of illness in 1933. Has there ever before been, may there ever again be, so great individual accomplishment in critical botanical indexing? Farlow's plan of 1874 could not possibly have anticipated the rapid rise in amount and diversity of literature to be reviewed or in uses to be made of such indexes. He must have conceived them as primarily for individual guidance in at once increasing personal understanding of the North American fungi and ultimately in preparing monographic publications. These purposes would have been suggested in his early associations with Gray and deBary, each of whom was in his own field the master botanical monographer of his time. Farlow's recognition of the need of such mycological monographing is shown in his preface to the Bibliographical Index where he notes the lack since those of deSchweinitz in 1822 and 1834. Doubtless the same idea had challenged other mycologists during the ensuing half century, but of these only one, Curtis, could have met it well. Curtis indeed so planned and his private herbarium was to have been the basis for this. It seems significant therefore that even while Farlow was with deBary in Europe in 1873, Dr. Gray purchased for him the Curtis herbarium. This nucleus of

the present Farlow herbarium awaited his return to Cambridge in 1874, with sets of the early European exsiccatae and the associated European literature, the beginning of the Farlow library. Here then at the very outset of modern American mycology Farlow began assembling the resources for such monographic studies, needing only the indexes to render these resources readily available. Seymour with Burrill's advice went, therefore, eagerly to join in the work with these, temporarily in 1883 and 1884 and permanently in 1886. Farlow was fortunately able to back his stimulating ideals by continuing throughout his life the enrichment of his herbarium and library upon which the indexing began and by final bequest providing a life annuity for Seymour as supplementing his Harvard salary. Farlow's support was matched, in turn, by Seymour's idealistic faith in the significance of this service to American mycology. To him the one regret was the forced relinquishment of personal researches upon the parasitic fungi. But whatever the task required was unstintingly rendered.

Thus the indexes grew apace with definite continuity in purpose and execution. Their wider usefulness became obvious with the emergence of economic mycology in the late eighties. Farlow at once responded to this with timely publications in the Harvard Library series. These opened in 1887, with the Farlow-Trelease "List of Works on North American Fungi," followed in 1888 by a supplement. Valuable as these were, the next in the series were even more so. In 1888 came Part I of the Farlow-Seymour "Provisional Host Index of the Fungi of the United States"; Part II followed in 1890 and Part III in 1891. Nothing of its kind could have been more timely or widely welcomed and therefore more encouraging to Seymour. Their reception seemed, indeed, but prophetic of far greater satisfactions to come if only he pushed his part in the work.

The card indexes were resolved into three interrelated parts, the author's index, the host index, and the species index. The publications had thus proceeded logically from the more exact and less bulky author's index to the host index. But the greater tasks with correspondingly greater significance lay in the yet unpublished species index. The widespread interest in and value of this became so obvious that the Carnegie Institution, in 1903, undertook

its publication. So great were the editorial burdens that actual publication was, however, delayed until 1905. Then appeared the first part of the first volume of Farlow's "Bibliographical Index of North American Fungi." This included all species alphabetically from *Abrothallus* to *Badhamia,* with exact citations to literature and carefully edited notes, chiefly by Farlow but some signed by Seymour. Farlow's preface to this not only indicated the continuance of this species index, but also stated that a new edition of the author's index was in preparation with additions up to 1905. For reasons unexplained, nothing more was published during Farlow's lifetime. Perhaps the experience with this single volume revealed unforeseen problems both as to labor and finance associated with the species index and these in turn inhibited the simpler tasks with the others.

The immediately pertinent thing in this article, however, is to record the significance of this situation to Seymour personally. Both the quantity and the complexity of the material to be indexed was increasing annually while his youthful vigor was waning. Therefore, the more trying was the necessity for persistance in the routine when the possibility of publication became ever more remote. Each new case of cards must add pro-rata to printing costs. In 1905 in the preface to the Bibliographic Index, Farlow estimated that up to 1903 about 150,000 references had been covered. When Part I of this appeared it seemed that on that date, 1905, its 305 pages might represent but little over five per cent of the total matter, which might then have filled over 5000 pages in 18 like volumes. What was each year to add to this? And yet the greater the growth, the more the need. In the preface Farlow states "The need of such an index has been felt in all our universities where the study of descriptive mycology is being pursued, as well as . . . experiment stations and other government establishments devoted to vegetable pathology. In the absence of such an index it has been necessary for different institutions to spend time and money in duplicating the work begun by us in 1874, and for a long time we have wished to publish our index . . . in order that it might be used by all. . . ." Farlow's statement of 1905 is far more pertinent today than then. The need as he defined it for the published index is universally felt. American

students of mycology, including all plant pathologists, are waiting and hoping that something may soon be done to carry out Farlow's wish of 1905, and make the species index generally available.

Fortunately the last decade of Seymour's life was made happier by the partial realization of his long-deferred hopes as to publication. In 1929 the Seymour Host Index of the Fungi of North America was issued by the Harvard University Press. As the writer in reviewing it then stated it represents "the seemingly impossible dream of many a youthful mycologist brought to realization." At least it meant that to Seymour; a partial reward for over 40 years of persistent work. Whereas the Farlow-Seymour Provisional Host Index of 1889–1891, with 213 pages, listed some 23,000 names of host and fungus, this final publication of 1929, with its 717 double-column pages, increases the citations of such names to some 80,000. The meticulous care in outlining his methods and rules in the Preface shows how consistently Seymour in this volume strove to maintain the exacting standards set by Farlow for the earlier series of Harvard Index publications. Seymour dedicated this last volume to the memory of William Gilson Farlow and records his indebtedness to Mrs. Farlow for constant interest in its preparation and material assistance in its publication. The dignity and worth of this Host Index is a constant reminder to American mycologists of the continuing need, as defined by Farlow thirty years ago, for the completion of publication of the author index and even more especially of the species index. When, and if, this need may be met and this long-deferred hope brought to realization, the dedication of the further volumes should be to Farlow and Seymour jointly that our enduring indebtedness may be thus acknowledged for the unique services to American mycology rendered by these two men.

In closing no fitter words are needed as to Seymour's part in this than those he inscribed on the fly leaf of the writer's copy of the Host Index; words which are an epitome of Seymour's life ideals—

> "A work of earnest friendship throughout.
> Keep the faith with those whom you can help."

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In addition to the above, Seymour wrote many short articles for popular magazines and a few notes in botanical periodicals, especially in the earlier part of his life. He also wrote chapters on spore plants in Bergen's "Foundations of Botany."

SOME NEW OR NOTEWORTHY FUNGI ON ERICACEOUS HOSTS IN THE PACIFIC NORTHWEST[1]

S. M. Zeller

(WITH PLATE 33 AND 5 TEXT FIGURES)

Many plants belonging to the Ericaceae are native to the Pacific northwest and are subject to infection by a list of very interesting parasitic fungi as well as serving as host to many saprophytic species. A few of the new or noteworthy ones are discussed in this paper in which the Ericaceae is taken in the broader sense to include those plants which are placed by some botanists in a separate family, Vacciniaceae. The fungi are taken up alphabetically under the greater groups, in the following order: Ascomycetes, Basidiomycetes, and Fungi Imperfecti.

1. Cenangella Rhododendri (Cesati) Rehm.

On the seed capsules and stems of the inflorescence of *Rhododendron californicum*, on Still Creek, Clackamas county, Oregon, June. Collected by *C. R. Stillinger* and *L. N. Goodding*.

So far as the writer is aware, this is the first report of this species from America. The Oregon material answers Rehm's description of the European type very closely, except that the spores in ours are mostly 19–22 × 7 μ, while the descriptions give 15–20 × 4–6 μ. A few pycnidia of *Diplodina Eurhododendri* Voss were found associated, as reported in Europe. These pycnidia are 150–300 μ in diameter with pycnidiospores 11–14 × 2.5–3.5 μ.

2. **Dermatea brunneo-pruinosa** sp. nov.

Apothecia superficial, 0.6–2 mm. diam., closed at first then cup-shaped, sessile to short-stipitate; *exterior* powdery villose, fawn-colored to wood brown, because of brown, septate hyphae with swollen cells toward tip; *hymenium* fuscous black because of the

[1] Published as Technical Paper No. 212 with the approval of the Director of the Oregon Agricultural Experiment Station. Contribution from the Department of Botany.

brownish tips of the paraphyses which form an epithecium, 130–160 μ thick, hyaline below; *asci* hyaline, clavate-cylindrical, 120–140 $\times$ 10–14 μ; *spores* ellipsoid, hyaline, 1–2-guttulate, one-seriate, 14–20 $\times$ 7–10 μ; *paraphyses* slender, clavate, and light brown above, 4–6 μ broad at tip; *medullary* tissues a hyaline pseudoparenchyma, thick; *hypothecium* thin, of interwoven hyphae.

Type in O. S. C. Herb., *8096*, collected by F. P. McWhorter near Hauser, Coos county, Oregon, March 22, 1932.

On large dead spots on living leaves of *Gaultheria Shallon*. Common in western Oregon and Washington. This fungus is constantly associated with the leaf spot caused by *Pestalozzia gibbosa* Harkness and may always follow as a saprophyte on dead leaf areas produced by the latter. Since *Gaultheria Shallon* is affected by so many leaf spotting fungi throughout its distribution, however, and *Dermatea brunneo-pruinosa* is always found on the one caused by *Pestalozzia gibbosa* Harkness there is circumstantial evidence that the two are organically connected.

3. **Lachnum Gaultheriae** (Ellis & Ev.) Zeller, comb. nov. (syn. *Dasyscypha Gaultheriae* Ellis & Ev.).

On the under surface of a large leaf-spot of *Gaultheria Shallon*. Common, February to July (PLATE 33, FIG. 1).

The leaf-spot with which this fungus is associated is large and circular, 2–4 cm. in diameter, pinkish-gray to grayish-white above, rusty brown below, with a purplish-black, smooth border. In almost every particular this fungus is similar to *Lachnum echinulatum* Rehm. and possibly should be so referred. The latter, however, is a promiscuous, folicose saprophyte and *L. Gaultheriae* seems to be parasitic, constantly associated with a definite type of leaf-spot of *Gaultheria Shallon*, a host susceptible to several fungi, each of which causes a characteristic leaf-spot. Ellis and Everhart first described this fungus as *Peziza* (*Dasyscypha*) *Gaultheriae*.[2]

Another very closely related species of *Lachnum* should be mentioned in this connection since it is reported on an ericaceous host, *Vaccinium*. This was distributed by Ellis and Everhart[3] as *Pe-*

[2] Ellis, J. B., and B. M. Everhart. New West American Fungi. Erythea 1: 199–200. 1893.

[3] Ellis and Everhart. North American Fungi No. *2144*.

ziza virginella Cooke and appears in Saccardo [4] under the name *Dasyscypha virginella* (Cooke) Sacc.

This is another typical *Lachnum* and is thus recombined as **Lachnum virginellum** (Cooke) Zeller, comb. nov. The spores are much longer than those of *L. echinulatum* Rehm. or *L. Gaultheriae,* but otherwise is similar to both.

4. LEPTOSPHAERIA GAULTHERIAE Dearn.

Common on ashy colored bark of dead stems of *Gaultheria Shallon.* The lesions are distinctly margined by a line.

5. **Lophodermium melaleucum** (Fries) De-Not. var. **epiphyllum** var. nov.

Maculae circular, ashy-gray, 3–4 mm. in diameter; *perithecia* epiphyllous, innate, oblong, about 600 × 300 μ, black, smooth, opening by longitudinal slits; *asci* long-cylindrical, 96–110 × 7 μ, 8-spored; *spores* filiform, hyaline to straw-colored, 60–67 × 2–2.5 μ.

On gray spots on living leaves of the evergreen huckleberry, *Vaccinium ovatum.* Waldport, Lincoln county. October.

This variety differs from the species in that the perithecia are always on the upper surface of the leaves. This is also true in *L. Oxycocci* but in that species the spores are much shorter.

6. MYCOSPHAERELLA ARBUTICOLA Peck.

On leaves of *Arbutus Menziesii,* Josephine county near Waldo, Oregon. February and June.

This is a very destructive parasite sometimes causing nearly a complete defoliation of the trees. (PLATE 33, FIG. 2.)

7. MYCOSPHAERELLA CHIMAPHILINA (Sacc.) House.

Causing leaf spot of *Chimaphila umbellata.* Common in western Oregon and Washington.

In our material the perithecia are 70–90 μ in diameter and the spores average 14 × 4 μ and are hyaline. The western form then is not *M. Chimaphilae* Ellis & Ev. and is not synonymous with *Stigmatea Pyrolae* (Fries) Schröt. as given by Trotter.[5] The

[4] Saccardo, Syll. Fung. **8**: 444.
[5] Saccardo, Syll. Fung. **24**: 397. 1926.

perithecia are embedded in the leaf tissue, subepidermal; aparaphysate.

8. MYCOSPHAERELLA GAULTHERIAE (Cooke & Ellis) House.

On *Gaultheria Shallon*, Waldport, Oregon; April.

This fungus is associated with a very prevalent leaf spot, which detracts greatly from the beauty of this broad-leaved evergreen.

9. PHACIDIUM GAULTHERIAE Dearn.

On whitened spots on the stems of *Gaultheria Shallon*. Throughout the range of the host these characteristically white spots margined by a raised line may be easily identified.

10. PHACIDIUM VACCINII Fries.

On dead fallen leaves of *Rhododendron californicum*, Douglas county, Oregon; March.

The Oregon material conforms more nearly to the description of this species than any other. The asci are 45–63 × 7–8 μ and the spores are broadly lenticular, 10–11 × 3–4 μ.

11. RHYTISMA ARBUTI Phillips.

On leaves of *Arbutus Menziesii* throughout the range of the host. Earlier on the same leaves *Melasmia arbuticola* Vize. occurs, causing an unsightly appearance, especially to the everegreen leaves which have over-wintered. This is perhaps the most common leaf-spotting fungus on this host, doing considerable damage in southwestern Oregon.

12. CHRYSOMYXA PIPERIANA (Arthur) Sacc. & Trott.

Rust on leaves of *Rhododendron californica*, Clackamas and Curry counties, Oregon. April to September.

This rust was previously reported and illustrated by Schmitz and need not be discussed further here.

13. **Exobasidium Burtii** sp. nov.

Causing circular buff spots on the leaves of the small-flowered *Azalea* (*Rhododendron albiflorum*). Very common on this host throughout its range.

This is the species of *Exobasidium* which Burt [6] has discussed and placed with doubt under *E. Vaccinii*. He "referred here, with some doubt, the *Exobasidium* causing yellow-buff leaf spot galls on *Rhododendron albiflorum*, collected on mountains in Washington by W. N. Suksdorf. The basidia are 20–30 × 6 μ,

FIG. 1. Leaf-spot of *Rhododendron albiflorum* caused by *Exobasidium Burtii*.

with 4 prominent sterigmata; the basidiospores are mostly 18–21 × 4.5–6 μ, and are nearly all 3-septate. Some of these spores are germinating, hence the septation of the spores may possibly be due to their over maturity when collected, combined with

[6] Burt, E. A. The Thelephoraceae of North America IV. *Exobasidium*. Ann. Missouri Bot. Gard. **2**: 627–658. 1915. (See p. 650.)

weather conditions at that time favorable to germination. Other collections which show the full series of gall forms on this host are desirable and should give the needed information in regard to septation of the spores."

Recently advantage was taken of an opportunity to study this disease on the Skyline Trail of the Cascade Range, from Olallie Lake to Breitenbush Lake, Jefferson county, Oregon. The observations were made the latter part of August, 1931, after a long, dry summer. Especial attention was given to the conditions mentioned by Burt but under all conditions the spores were found to be septate. Conditions were not at all conducive to spore germination, nor had they been for several weeks.

Since Dr. Burt hinted that this *Exobasidium* is perhaps distinct from *Exobasidium Vaccinii,* I take pleasure in dedicating it to him.

Leaf spot, yellow-buff above, lighter below, usually 1–2 cm. in diameter, flat; basidia hypophyllous, 4-spored, 18–28 × 5–7 μ; *sterigmata* stout, prominent; *basidiospores* early 3-septate (sometimes one cell septate lengthwise), 17.7–24 × 5–6.5 μ, hyaline, ellipsoid to allantoid; *conidia* abundant, hyaline, continuous, narrow cylindric, usually straight, 0.7–1.5 × 7–13 μ.

This species is between *E. Vaccinii* and *E. Vaccinii-uliginosi* in breadth of spores, and differs also from both in color and type of leaf spot and early septation of spores. A leaf spot of similar color but more brownish buff and with reddish margins, is caused by *E. Vaccinii* on *Vaccinium membranaceum, V. Myrtillus,* and *V. parvifolium.*

When the plants of *Rhododendron albiflorum* are well infected they appear variegated, as in text figure 1.

14. EXOBASIDIUM LEDI Karsten.

Forming purplish-gray, bladder-like galls on leaves of *Ledum glandulosum* Nutt., 12 miles northeast of Pierce, Clearwater National Forest, Idaho.

This collection was taken by J. R. Hansbrough and J. L. Mielke, July 31, 1931, and constitutes our only record of *Exobasidium* on this host in the northwest. It is morphologically similar to *E. Vaccinii* and doubtless Burt would include it there, but without cross-inoculation study I am using Karstens' name. The collectors say it is common and abundant in the Idaho locality.

15. EXOBASIDIUM PARVIFOLII Hotson.

Causing clavaria-like proliferations from canker-gall spots on stems of *Vaccinium parvifolium* Smith. Collected by the writer in Benton and Coos counties in June. Both collections were typical and very different from *E. Vaccinii* on the same host. This has been described in detail by Hotson.[7]

16. EXOBASIDIUM VACCINII (Fuckel) Wor.

This species attacks many different host plants belonging to the Ericaceae. In the Pacific northwest it occurs on the leaves of the Madrone (*Arbutus Menziesii*), the manzanitas (*Arctostaphylos manzanita, A. nevadensis, A. columbiana,* and *A. Uvi-ursi*), cultivated azaleas in greenhouse and gardens, *Cassiope mertensiana,* wild cranberry (*Oxycoccus oxycoccus intermedium*), Fool's huckleberry (*Menziesia ferruginea* and *M. glabella*), western *Rhododendron* (*Rhododendron californicum*), cultivated species of *Rhododendron,* and various species of *Vaccinium,* as *V. deliciosum, V. membranaceum, V. Myrtillus, V. ovalifolium, V. ovatum* (and its blue-berried variety, *V. ovatum saporosum*), and *V. parvifolium.*

In this listing of hosts I have followed Burt who has included all of these host genera in his list of hosts for this species providing the spore measurements conform with those of the typical *E. Vaccinii.* Burt perhaps on the same grounds would have included *E. Ledi* here, had he observed American material. Cross-inoculation may prove several species are included here as described in previous literature.

Suffice it to say here that collections on one or another host have been observed from all types of locations in the northwest from sea level to 3500 to 4000 feet elevations.

17. EXOBASIDIUM VACCINII-ULIGINOSI Bond.

This species occurs on several hosts in the Pacific northwest, although Burt [8] had but one American specimen to cite. This was what Burt calls a "shoot gall" and others have termed "rose bloom," on *Vaccinum membranaceum.* In this type of infection

[7] Hotson, J. W. A new species of *Exobasidium.* Phytopath. **17**: 207–216. *Illus.* 1927.

[8] Burt. Loc. cit.

characteristic of *E. Vaccinii-uliginosi,* all of the leaves above the point of infection are felty-white below and red or pinkish above. The mealy white felt below is made up mostly of basidia and basidiospores but on some hosts, especially *Rhododendron californicum,* many conidia are produced. The basidiospores are 7–9 μ in width, while in *E. Vaccinii* they are 2.5–4 μ wide and in *E. Burtii* they are mostly 4.5–6 μ wide.

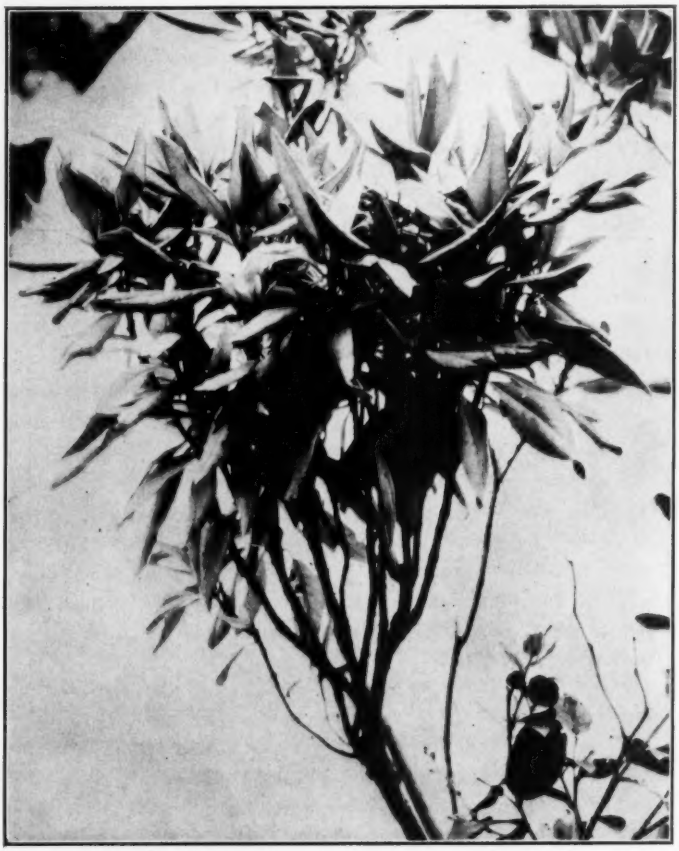


FIG. 2. Witches' broom of *Rhododendron californicum* caused by *Exobasidium Vaccinii-uliginosi.*

E. Vaccinii-uliginosi causes a distinct witches' broom with white (pinkish) leaves on *Rhododendron californicum*. Undoubtedly this is the witches' broom and white leaf to which Schmitz [9] has referred. This disease does considerable damage to the *Rhododendron* in the Cascade mountains. It is so characteristic in appearance that it cannot be mistaken (TEXT FIG. 2).

E. Vaccinii-uliginosi also causes a distinct witches' broom of *Vaccinium ovatum* (TEXT FIG. 3), and "shoot galls" of *Arctostaphylos columbiana* and *Phyllodoce empetriformis*. The dis-

FIG. 3. Witches' broom of *Vaccinium ovatum* caused by *Exobasidium Vaccinii-uliginosi*.

ease of *A. columbiana* is very common and is typical of the European material such as distributed by Briosi & Cavara *261*.

18. FOMES ARCTOSTAPHYLI Long.

Causing serious heart rot of *Arctostaphylos columbiana* and *A. patula*, east and west of the Cascade mountains in Oregon.

Since Long included no illustrations of this fungus with the original description [10] I am taking the liberty to include here one showing a sporophore on *A. patula* (TEXT FIG. 4) and the type of decay produced (TEXT FIG. 5).

[9] Schmitz, H. Observations on some common and important diseases of the *Rhododendron*. Phytopath. **10**: 273–278. *Illus.* 1920. (See *Pl. XI, fig. 3.*)

[10] Long, W. H. Three undescribed species of polypores. New Mex. Chap. Phi Kappa Phi, Papers **1**: 1–3. 1917.

Although Murrill has reduced this form to synonymy with *Fomes igniarius,* I am inclined to Long's viewpoint—that it is a distinct species. It is smaller than *F. igniarius,* produces a distinct rot which does not have the delimiting, definite black line, and grows differently in culture. Setae have not been found in the Arizona nor Oregon specimens while *F. igniarius* has setae at least sparsely distributed in the hymenium. This is a very common rot of manzanita in southwestern and central Oregon where it is difficult to find plants which are not affected.

FIG. 4. *Fomes Arctostaphyli* Long on *Arctostaphylos patula.*

19. CRYPTOSTICTIS ARBUTI (Bonar) Zeller.[11]

Syn. *Disaeta Arbuti* Bonar, Mycologia **20**: 299–300. 1928.

Associated with a leaf spot of *Arbutus Menziesii* from Josephine to Douglas county, with a leaf spot of *Ledum glandulosum* Nutt.

[11] Zeller, S. M., and J. W. Deremiah. An anthracnose of *Ledum* caused by a species of *Elsinoë.* Phytopath. **21**: 972. 1931.

all along the west coast of Oregon, and with a leaf spot of *Arctostaphylos columbiana* from Canyonville, Douglas county, and Waldport, Lincoln county, Oregon. May to December.

This species was described by Bonar from material collected in Alameda and Marin counties, California. The new genus, *Di-*

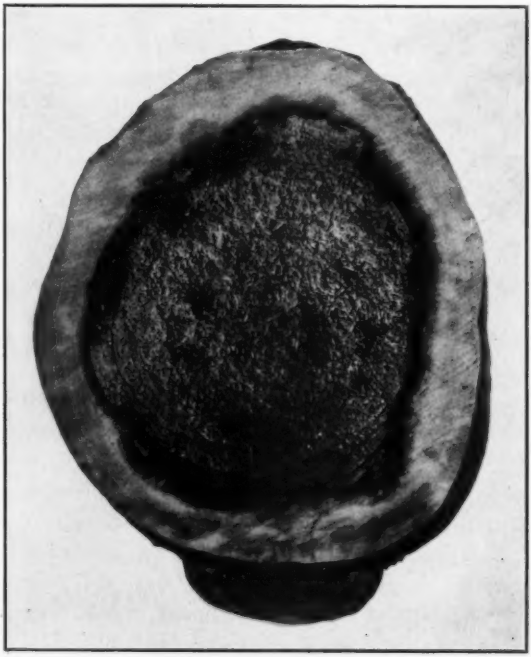


FIG. 5. Rot of *Arctostaphylos* wood caused by *Fomes Arctostaphyli.*

saeta, was based on this species, but a study of type material collected on Mt. Tamalpais, California, shows this to be typical of *Cryptostictis.* The material on *Arbutus* collected in Oregon agrees in every way with the type material and it is believed that the collections on *Ledum glandulosum* and *Arctostaphylos columbiana* are sufficiently similar to be referred here (PLATE 33, FIG. 3).

The leaf spots on *Ledum* and *Arctostaphylos* are mostly circular or occupy a whole leaf tip, 5–12 cm. broad, zonate with central

zones, grayish to light brown, and marginal zones dark brown, fringed with purplish tones. The fungus itself is as found on *Arbutus*. It may be that the setae of the spores are more flexuous in specimens from *Arbutus*, where they are often as long as the spores. On the three hosts the spores are constantly 4-septate.

Another species of *Cryptostictis* on an Ericaceous host in Oregon is *C. Mariae* on *Rhododendron*, reported below. This species differs from *C. Arbuti* chiefly in the 5-septate spores. Otherwise there could be little cause for designating them as separate species.

20. CRYPTOSTICTIS MARIAE (Clinton) Sacc.

Associated with a leaf spot of *Rhododendron californica*, throughout the range of the host in the Pacific northwest. January to October.

This fungus is constantly associated with a characteristic leaf spot of this host in the northwest. The spots are brown, being lighter toward the center, giving a "bull's eye" effect. This is exaggerated by the concentric lines of acervuli of the fungus. The spots are 4–25 mm. in diameter and when plentiful are ruinous to the appearance of this beautiful, wild shrub (PLATE 33, FIG. 4).

The Oregon material is identical in morphology to cotype material (Forestburg, N. Y.) kindly loaned by Dr. H. D. House.

Undoubtedly *C. Mariae* is the species which Schmitz [12] has mentioned as the cause of a leaf spot of *Rhododendron* and it is the disease which has usually been referred to as the *Coryneum* leafspot caused by *Coryneum Rhododendri* Cooke. This mistake is easily made when dried material is examined. Under such conditions during the preparation of microscopic mounts the brittle setae are broken from the spores. On the other hand, if fresh material is examined or if dry material is previously moistened with water for a few minutes before disturbing, the setae of the spores will usually remain intact.

Coryneum Rhododendri Cooke doubtless occurs in the northwest, as mentioned by Schmitz [13] but we have not seen it. The material referred to by the writer [14] in 1929 proves to be *Cryptostictis Mariae*.

[12] Schmitz, H. Some common and important diseases of *Rhododendron*. Phytopath. **10**: 277–278. 1920.

[13] Loc. cit.

[14] Zeller, S. M. Oregon fungi. Mycologia **21**: 109. 1929.

21. **Didymosporium arbuticola** sp. nov.

Maculi brown in center, purplish to reddish margins, 3–6 mm. in diam., sometimes coalescing; *acervuli* maculicolous, hypophyllous, circular, 130–240 μ broad, erumpent, breaking with a stellate margin of grayish epiderm; *conidiophores* hyaline, short, simple; *conidia* acrogenous, oblong-ellipsoid, usually straight, 1-septate, slightly constricted at septum, sometimes 3-septate, dark brown *en masse*, light brown or olivaceous under lens, 19–29 $\times$ 7–8 μ (ave. 23 $\times$ 7.25).

On living leaves of *Arbutus Menziesii*, Corvallis, Oregon. December. (Type in Oregon Agr. College Herb. *4891.*) (PLATE 33, FIG. 5.)

It may be that since some spores become 3-septate this species should be referred to *Coryneum* but I have referred it to *Didymosporium* because most of the spores seem to be 1-septate and the 3-septate spores are usually constricted at the middle septum but not at the other two. Perhaps folicose forms like this should be referred to Spegazzini's genus *Phaeomarsonia*. Three-septate spores up to 35 μ long have been occasionally observed (PLATE 33, FIG. 6).

22. MELASMIA MENZIESIAE Dearn. & Bartholomew.

On leaves of *Menziesia ferruginea*, Tillamook and Clackamas counties, Oregon. Late summer.

A very interesting " tar spot " fungus.

23. PESTALOZZIA GIBBOSA Harkness.

On large zonate spots of living leaves of *Gaultheria Shallon*. Common in the coastal zone of western Oregon and Washington.

The leaf spot caused by this fungus is very large, often involving most of the leaf surface. They are typically zonate, the central portion grayish encircled by a light brown band which is bordered by a dark purplish broad line.

The spores of the fungus are very characteristic being 4-celled with one large dark cell and the appendages with knobbed extremities.

On the spots caused by this fungus *Dermatea brunneo-primosa* Zeller occur early the following spring.

24. PHYLLOSTICTA RHODORAE (Cooke) Tass.

Causing large brown spots on the leaves of *Rhododendron californica,* Mud Creek, and Shell Rock Lake, Clackamas Co., Oregon, June and July. Collected by L. N. Goodding and A. L. Hinkley, and G. D. Darker and L. N. Goodding, respectively.

In this collection the pycnidia are 100–160 μ in diameter and the spores are ellipsoid and 3.5–4 $\times$ 2–2.5 μ. In these respects it also answers the description of *Coniothyrium Rhododendri* P. Henn. but in this Oregon material the spores are colorless. The spots with which this fungus is associated are large and brown like a sun scorch and have the irregularly wavy curved margins so often seen when leaves are scorched. The pycnidia are black dots on these brown areas.

25. SEPTORIA SOLITARIA Ellis & Ev.

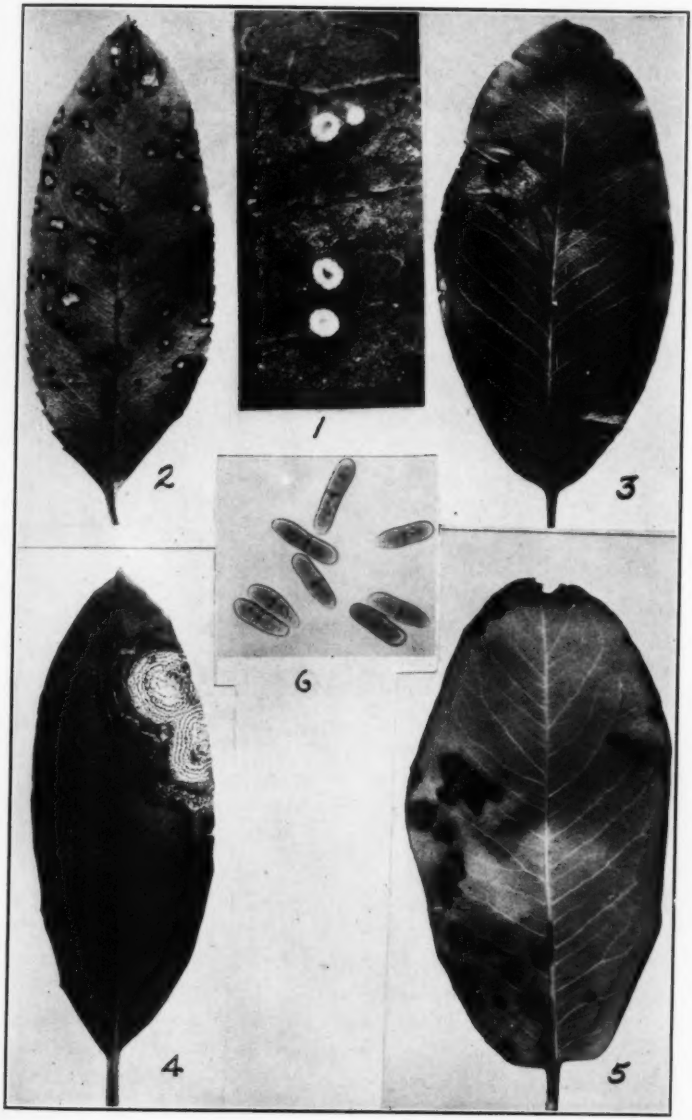
On leaves of the western azalea, *Azalea occidentalis,* along the coast, Coos and Curry counties, Oregon. July. Coll. *L. N. Goodding.*

This is perhaps the same species of *Septoria* which Ellis and Everhart so inadequately described. The spores in the Oregon material vary from 18 to 53 μ in length but they are mostly 35–50 μ, while those of *S. solitaria* were described as 20 $\times$ 2 μ. The name, however, is very appropriate for our material in which most of the leaf spots have a solitary black pycnidium standing out rather conspicuously on the ashy white background. The leaf spot is rather serious in certain locations.

OREGON STATE COLLEGE,
CORVALLIS, OREGON.

EXPLANATION OF PLATE 33

Fig. 1, *Lachnum Gaultheriae* on leaf of *Gaultheria Shallon,* $\times$ 8; 2, leaf-spot of *Arbutus Menziesii* caused by *Mycosphaerella arbuticola;* 3, leaf-spot of *Arbutus Menziesii* caused by *Cryptostictis Arbuti;* 4, leaf-spot of *Rhododendron californicum* caused by *Cryptostictis Mariae;* 5, leaf-spot of *Arbutus Menziesii* caused by *Didymosporium arbuticola,* showing lower leaf surface; 6, spores of *D. arbuticola,* $\times$ 400.



FUNGI ON ERICACEOUS HOSTS

INVESTIGATIONS OF TWO-SPORED FORMS IN THE GENUS MYCENA [1]

ALEXANDER H. SMITH

(WITH PLATES 34–38)

INTRODUCTION

It has long been known that within the genus *Mycena* there exists an unusually large number of forms bearing basidia which produce two instead of the usual four spores. In recent years even more variation has been noticed (Oort, **19**). In general the use of the two-spored basidium as a character of taxonomic importance in the Agaricaceae has been questioned. There still seems to be a difference of opinion, however. Lange (**13**, **14**) by using this character in keying out species of *Mycena* and *Omphalia*, and in describing a two-spored species of *Tricholoma* has given it considerable weight. Kauffman in his unpublished manuscript on *Mycena* had also placed considerable emphasis on the two-spored character, chiefly it seems, because in *Mycena* an increase in spore size usually accompanies the change from the four- to the two-spored basidium.

In comparatively recent times considerable emphasis has been given to cytological and genetical studies of two-spored forms in the Agaricaceae and related families. The investigations of Bauch (**1**, **2**), Buhr (**4**), Fries (**5**, **6**), Harper (**7**), Juel (**8**), Kühner (**10**, **11**, **12**), Lewis (**16**), and Sass (**20**, **21**) have given much information concerning the types of nuclear behavior in scattered species throughout most of the families of higher Basidiomycetes. In most species with two-spored basidia it has been found that there is a fusion of two primary nuclei in the basidium and that in the Agaricaceae, as a rule, two divisions follow before the spores mature. In the Clavariaceae three divisions are usually found. In the Agaricaceae, depending on the species, all of the four nuclei

[1] Papers from the Department of Botany and the Herbarium of the University of Michigan, No. 455.

may migrate or two may degenerate in the basidium. A few forms have been described which are parthenogenetic. In the latter the young basidium contains only a single nucleus.

Since no intensive study had been made involving both those species which are known to have four- and two-spored forms, and those isolated species in which only two-spored basidia are known, it seemed very desirable to investigate as many of both types as could be found in a single genus in order to furnish, if possible, a better understanding of the position of two-spored forms in the classification of agarics, and in addition to obtain information concerning the nuclear history in a large number of closely related variant forms. The genus *Mycena* seemed to be a particularly favorable group of species for such an investigation because of the relative abundance of material, and because of the fact that both of the types of nuclear history mentioned above had previously been found among its species.

The writer wishes to express his appreciation to Professor E. B. Mains for advice and guidance during the course of the present investigation, and to Professor W. R. Taylor for his interest and helpful suggestions in the cytological studies.

MATERIALS AND METHODS

Since few cytological investigations have previously been made on species of *Mycena*, *M. alcalina* Fries, *M. Atkinsoni* House, *M. hemisphaerica* Peck, *M. haematopoda* Fries, *M. leptocephala* Fries, *M. murina* Murr., *M. sanguinolenta* Alb. & Schw., *M. stannea* Fries and *M. viscosa* Maire were studied in order to establish the usual type of nuclear behavior. The following nineteen variant forms were investigated: *Mycena alcalina* Fries, *M. capillaris* Fries, *M. citrinomarginata* Gillet, *M. clavicularis* Fries, **M. cholea** sp. nov.,[2] *M. graveolens* Kauff. & Smith, *M. immaculata* Peck, *M.*

[2] **Mycena cholea** sp. nov.—Statura Mycenae vitilis; pileus 2–12 mm. latus, obtuse conicus demum campanulate expansus, fuscus vel bruneolus, expallescens, striatus, non pruinosus; lamellae subconfertae, adnatae, albidae interdum pallide sordidae; caro incisa demum incarnata, sapore quininae simili, praecipue in stipite succosus, succo lacteo non copioso; stipes (1) 3–6 (10) cm. longus, 1 mm. crassus, fuscus demum pallidus; sporae 9–11 (12) × 6–7.5 (8) μ, ovoideae; basidia bispora; cystidia numerosa, apice cuspidata, 55–80 × 10–14 μ. Specimen typicum in Herb. Mich. conservatum, A. H. Smith n. 32–545, prope Ann Arbor, Mich. Oct. 8, 1932.

lasiosperma Bres., *M. dissiliens* Fries, *M. leptocephala* Fries, *M. margaritispora* Lange, *M. megaspora* Kauff., *M. metata* Fries, *M. mirata* Peck, *M. polygramma* Fries var. *albida* Kauff., *M. roseipallens* Murr., *M. rubromarginata* var. **Laricis** var. nov.,[3] *M. viscosa* Maire, and *M. vitilis* Fries.

The cytological studies have all been made from fruit-bodies collected in the vicinity of Ann Arbor. Because many of the species in this genus are very small and delicate it is desirable to kill and fix them for cytological study in the field when they are collected. In killing such material it is necessary to remove the air from between the lamellae in order to obtain the best results. It was found that by reversing the leather on the plunger in an ordinary tire-pump, and fitting the rubber tube with the proper connections, a very effective apparatus could be made. It gave rapid evacuation without damage to the delicate lamellae, and could conveniently be carried into the field.

The most satisfactory killing solutions were those of Flemming in various dilutions, and the following two known as Allen's modification of Bouin's solution.

1. After La Cour (15)		
Picric acid, sat. aq. sol.	75.0	cc.
Formalin	25.0	cc.
Acetic acid (Glacial)	5.0	cc.
Urea	2.0	gms.
Chromic acid	1.5	gms.
2. Picric acid, sat. aq. sol.	75.0	cc.
Formalin	25.0	cc.
Acetic acid (Glacial)	5.0	cc.
Urea	1.0	gm.
Chromic acid	0.5	gm.

The washing, dehydrating, and embedding were carried out in the usual manner. Sections were cut at thicknesses varying from

[3] *Mycena rubromarginata* var. **Laricis** var. nov.—Pileus 5–20 mm. latus, obtuse conicus, demum expansus et interdum late campanulatus vel convexus, glaber, striatus vel plicato-striatus, vinaceo-umbrinus, expallescens; lamellae pallidae vel cinerae, subdistantes vel distantes, adnatae, acie rubeola vel concolore; stipes pileo concolor, 2–4 cm. longus, 1–1.5 mm. crassus, glaber, fragilus; sporae 10–12 × 5–7 μ, subpyriformae; basidia 26–28 × 6–8 μ, bispora; cellulae aciei lamellarum subfusoideo-ventricosae, 40–75 × 5–12 μ. Hab. ad truncos laricinos. Specimen typicum in Herb. Mich. conservatum, A. H. Smith n. 32-229, prope Ann Arbor, Mich. June 17, 1932.

two to fifteen microns, depending on the tissue which was to be studied and the type of observation to be made.

Various stains were used, but for nuclear counts iron-alum haematoxylin with an orange G counter stain in clove oil proved to be most satisfactory. Feulgen's (**18**) reagent was tried on all of the species, but the resulting visibility as a rule was poor. In *Mycena capillaris,* however, it was the only stain which was reliable for nuclear counts, the others giving no differentiation whatever. Each species was a separate problem, but in general if haematoxylin was satisfactory, the other stains were also, and if the haematoxylin did not take readily, the others were equally unsatisfactory.

TAXONOMIC DATA

A careful taxonomic study has been made of all of the species in the genus which the writer has collected. In this study fruit-bodies with four-spored basidia were considered typical. Two-spored forms were referred to a species only when the fruiting bodies resembled those bearing the four-spored basidia in every respect except in the number of spores born on a basidium and in the size and shape of the spores. Fruiting bodies with only four-spored basidia will be referred to hereafter as "typical forms," while those showing variation, being either two-, three- and four-spored on a single pileus, two- and three-spored, or simply two-spored, will be referred to as "variant forms." During the course of the investigation a total of ninety-five typical and variant forms were collected in Michigan; twenty-seven of these are variants. Fourteen of the variants have been correlated with typical forms, seven determined but not correlated, and six remain unidentified.

The variant forms were mostly two-spored, but in practically all a few three-spored basidia were found. In *Mycena citrinomarginata, M. dissiliens, M. leptocephala,* and *M. polygramma* var. *albida* variant forms were found with two-, three-, and four-spored basidia on a single pileus. In all cases, even on a single pileus, the spores born on two- or three-spored basidia were found to be larger than those born on four-spored basidia. The following table summarizes the change in spore size which was found to

accompany a change in the number of spores produced on a basidium. The spores of some of the species are illustrated on plate 34.

TABLE 1

COMPARISON OF SPORE-SIZE OF VARIANT AND TYPICAL FORMS OF SPECIES OF *Mycena*

Species	Variant Form [4]	Typical Form
M. alcalina	11–12 × 6.5–8 μ	8–10 × 5–6 μ
M. capillaris	11–13 × 5–6 μ	8–10 × 4–5 μ
*M. *citrinomarginata*	12–14 × 5–6 μ	9–11 × 5–6 μ
M. clavicularis	10–12 × 5–6 μ	8–10 × 4–5 μ
*M. *dissiliens*	7– 8 × 7 μ	7–8 × 5–6 μ
M. epipterygia	10–12 × 6–8 μ	9–11 × 6–7 μ
M. graveolens	8–10 × 4.5–5 μ	7–8 × 4 μ
M. immaculata	8–10 × 2.7–3 μ	7–8 × 2.5–3 μ
M. lactea	7.5–8.5 × 6–7.5 μ	7–8 × 3–4 μ
*M. *leptocephala*	11–14 × 5–6.5 μ	7–10 × 4–5 μ
M. metata	8–9 × 4–5 μ	7–8 × 3–4 μ
*M. *polygramma* var. *albida*	9–11 × 6–7 μ	8–10 × 5–6.5 μ
M. roseipallens	7–8 × 5–6 μ	6–7 × 3–4 μ
M. supina	8–11 × 7–8 μ	7–8 μ
M. viscosa	9–11 × 6.5–8 μ	8–9 × 5–6 μ

[4] The forms commonly three-spored are marked with an asterisk.

In *Mycena dissiliens* and *M. polygramma* var. *albida* there is little difference in size, and the increase is so distributed that the shape of the spore in both species is practically unaltered. In *Mycena citrinomarginata* there is a substantial increase in the length but not in width, thus accentuating the somewhat cylindrical shape of the spore. The species *M. alcalina, M. capillaris, M. clavicularis, M. graveolens, M. metata,* and *M. viscosa* all show an increase in spore size, but scarcely any change in shape. In *Mycena roseipallens, M. lactea,* and *M. supina* a change in shape has accompanied the increase in size. In the first two the change is from a more or less ellipsoid spore to one which is subglobose. In *Mycena supina* the change is from a globose spore to one which is broadly ovate. In all of the forms studied the change was constant within a species.

CYTOLOGICAL AND CULTURAL DATA

The typical forms: Nine four-spored species have been studied cytologically. These show the usual nuclear history through the

meiotic divisions, and the reorganization of the four daughter nuclei. The young basidium is characterized by the presence of two nuceli which fuse to form a large fusion nucleus. The fusion nucleus divides in the upper part of the basidium, and two reorganized daughter nuclei are regularly found. Each of these divides once, and the resulting four nuclei move toward the base of the basidium. After the spores have started to form, the four nuclei elongate and migrate upward, each into a sterigma. However, instead of migrating on into the spore as is usually the case in other agarics, each nucleus divides, one of the daughter nuclei migrating into the spore and the other eventually returning into the upper part of the basidium. Distinct division figures (PLATE 35, FIGS. 9, 27) have been found in *M. Atkinsoni* and *M. viscosa*. As a result of this division, each spore receives one nucleus and four nuclei remain in the collapsing basidium (PLATE 35, FIG. 10). These residual nuclei are constantly present in the old basidia of all of the above species except *Mycena murina,* and while third division figures have not actually been seen for all, the presence of residual nuclei in the collapsing basidia is here considered as evidence that such a division occurred.

In *Mycena murina* a striking variation from this behavior is found. In this species the third division is irregular but characteristic, and all of the daughter nuclei migrate, two into each spore. While third division figures are occasionally found with their axes arranged parallel to the longitudinal axis of the basidium (PLATE 35, FIG. 21), they are usually arranged transversely (PLATE 35, FIG. 20). As is shown (PLATE 35, FIG. 20), each of the two poles of the uppermost division figure lies beneath a sterigma. Various other stages of the division and migration of the nuclei are shown (PLATE 35, FIG. 29, 25, 26, 30, 31). All of the old basidia in this species were completely empty.

It is evident that the arrangement of the spindles in the third division may possibly have an important bearing upon the genetical identity of the nuclei in the four spores. If the heterotypic division is either the first or second division in the basidium, and if the spindles of the third division are in the sterigmata and longitudinal, one would expect two daughter nuceli, identical genetically, to migrate into a spore. On the other hand, if the spindles of the

third division are arranged transversely and daughter nuclei migrated into different sterigmata, the pairs of nuclei seen in figure 26, plate 35 might be of different genetical constitution. Since both arrangements of the third division spindles have been found in the basidia of a single pileus, this species is particularly interesting from a genetical point of view.

The variant forms (usually two-spored): The variant forms studied fall into two types; those in which the young basidium contains two primary nuclei which fuse, giving rise to a fusion nucleus, and those forms with a single nucleus in each young basidium.

The "*Mycena metata*" group: The first group of species contains *M. metata, M. clavicularis, M. graveolens, M. immaculata, M. margaritispora, M. mirata* and *M. viscosa*. The species in this group are characterized by a fusion of two primary nuclei eventually followed by three divisions in the basidium. Since this type of nuclear behavior, with the exception of the third division, is well described in the literature, it will be outlined here briefly for only one species, *Mycena metata*. The cells of the subhymenium are typically binucleate, but occasionally the larger cells are multinucleate. As the young basidium elongates the two nuclei come to lie side by side in the midportion and usually fuse before the basidium has reached its full length. Apparently the fusion takes place rather slowly. The nuclei gradually lose their outlines at the point of contact and are then distinguishable as two granular masses with a darkly staining nucleolus in each.

As soon as the fusion is complete the spireme threads appear as rather coarse, heavily staining strands (PLATE 35, FIG. 40). The fusion nucelus is 3–4 μ in diameter and one or two nucleoli can be seen within it. It gradually increases in size and moves toward the apex of the basidium. Instead of migrating directly into the apex, it comes to rest some distance below it. Judging by the frequency of such figures in all of the preparations, this "resting stage" is one of long duration. Just prior to dividing the nucleus moves farther up toward the apex and the first division follows (PLATE 35, FIG. 41). The details of the division were not worked out, but the spindle is formed within the old nuclear membrane, and a centrosome is visible at each pole. A side view

of a metaphase plate shows that at this stage the whole figure is still within the space previously occupied by the fusion nucleus. However, during the anaphase the centrosomes move back toward the walls of the basidium and at the telophase the two masses of chromatin are often found appressed against the opposite walls. The fate of the nucleoli during the division is uncertain, but they seem to be extruded into the cytoplasm where they are then indistinguishable from other granules.

The figures of the second division are very minute, but metaphase and telophase stages are frequent (PLATE 36, FIG. 1, 2). The four reorganized daughter nuclei are very small at first. They soon increase to 1.5–2 μ, develop a delicate characteristic reticulum, and migrate toward the base of the basidium. This migration carries the nuclei into the more or less constricted portion of the basidium. Just before they come to rest near the base, the sterigmata begin to develop, first as two obtuse humps, but soon elongating and assuming their characteristic narrowly conical form.

When the spores are quite large, the four nuclei situated in the lower portion of the basidium move toward the sterigmata and become elongated or beaked. The behavior of the four nuclei from the time they first become beaked to the time when the two spores are mature seems to be rather variable. As is shown in plate 36, fig. 3, the spores begin to form before the nuclei elongate. The two nuclei which lie uppermost in the basidium migrate first. Figures can be found showing the first nucleus, after it has migrated to the apex of the spore, either in a resting condition or dividing. Figures of daughter nuclei can also be found indicating that a division has been completed. The second set of nuclei may enter the spores and divide immediately (PLATE 36, FIG. 4) leaving the basidium empty, or they may divide while in the sterigmata (PLATE 36, FIG. 5). Only one of the daughter nuclei of this division then passes into the spore. The divisions in the spores and sterigmata are rather haphazard. In plate 36, fig. 4, the nucleus nearest the sterigmata is shown dividing while the apical nucleus is in a resting condition. In plate 36, fig. 5, the nucleus in one spore and those in the sterigma are shown dividing simultaneously. In plate 36, fig. 6, two nuclei in one spore are shown in the resting condition while the one nucelus in the other spore and also the nucleus just

entering the latter, are shown in practically the same stage of division. One basidium showing two resting nuclei in one spore, and two dividing nuclei in the other was also found (PLATE 36, FIG. 7).

In *Mycena margaritispora* the situation seems to be similar to that found in *Mycena metata*, the third division figures occurring rather haphazardly in both spores and sterigmata. The manner of origin of the four residual nuclei (PLATE 36, FIG. 20) has not been determined. As shown (PLATE 36, FIG. 29), in *Mycena viscosa* all four nuclei may migrate, two into each spore, and then divide simultaneously, the basidium showing no residual nuclei. However, old basidia with residual nuceli are found in this species also. In *Mycena graveolens* two residual nuclei are commonly present, occasionally four, and very seldom none at all.

The material of *M. clavicularis* and *M. immaculata* was not favorable for studying the later stages.

The "*Mycena megaspora*" group: The species of this, the second group of variant forms, are characterized by the lack of a fusion of nuclei in the basidium, the single original nucleus eventually giving rise to four daughter nuceli. Twelve species, namely *M. megaspora, M. alcalina, M. capillaris, M. cholea, M. citrinomarginata, M. dissiliens, M. lasiosperma, M. leptocephala, M. polygramma* var. *albida, M. roseipallens, M. rubromarginata* var. *Laricis,* and *M. vitilis* have been found to belong to this type. All of these are similar to the two-spored form of *Camarophyllus virgineus* studied by Bauch (1) in that the subhymenial cells and young basidia each contain a single nucleus. Because there is no fusion of nuclei in the basidium, and because the same number of chromosomes was found in the nuclei of both two- and four-spored forms, Bauch has considered the two-spored form of *C. virgineus* to be parthenogenetic. In *Mycena alcalina* which has received considerable study, the writer's observations indicate that the chromosome number, as obtained from division figures in the basidia, is apparently the same in the two-, and the four-spored forms. Since this corresponds to Bauch's findings, the writer is classifying all the forms in the "*Mycena megaspora*" group as haploid parthenogenetic forms. In the treatment which follows, *M. citrinomarginata, M. dissiliens, M. leptocephala* and *M. polygramma* var. *albida* are considered separately because they illus-

trate the nuclear behavior in parthenogenetic forms producing two, three, or four spores on a basidium.

Since *Mycena megaspora* has been studied culturally and cytologically, it will be discussed here is some detail. This species has been cultured from transfers of tissue from the pileus, groups of spores sprayed on agar plates, and from single spores isolated by the spray method (**9**). No clamp connections were observed in any of the cultures. The fungus grows rather slowly covering the agar in an ordinary petri dish in six to eight weeks. A 2.5 per cent malt extract agar was the most favorable medium tried, and the optimum temperature was found to be between 23 and 25 degrees centigrade. Tissue cultures grew more rapidly than the single spore cultures, but there was no difference in the type of growth produced. The hyphae grew very closely together in a compact mat along the surface of the agar and produced a fluffy, white aerial growth. The medium was penetrated to a depth of one or two millimeters by a rather sparse growth.

Fifty single spores were isolated during the course of the work, and mating experiments were carried out in an attempt to obtain diploidization. Mycelia from spores from fruit-bodies collected in different localities were used in the mating experiments, but no clamp connections were produced. Since certain Basidiomycetes (**20**) are known to possess the dikaryophase without showing clamp connections on the mycelium, an attempt was made to study the mycelium obtained from tissue cultures and from single spores cytologically. Due to the slow and compact manner of growth the method recommended by Sass (**21**) failed to give any results, and it was necessary to kill and embed mycelium grown on agar plates. Sections were cut 12 to 25 μ thick and stained with iron-alum haematoxylin or safranin and light green. While this method has obvious disadvantages, it was found to be usable. As a check, the mycelium of *Collybia clusilis* Fries, a species which produces clamp connections abundantly, was carried through the same process. Slides of *C. clusilis* showed two nuclei in each cell and abundant clamp connections while the slides of *Mycena megaspora* showed one nucleus in each cell, or occasionally two or three in very large hyphae.

In the fruit-body the cells of the stipe were found to contain

from one to six or more nuclei depending on the size of the cell. The tissue of the stipe in this species is composed of large, straight, tubular cells as well as irregular hyphae of smaller diameter which lie intertwined among the larger elements. The individual cells of the irregular hyphae were usually found with one nucleus, while the enlarged, parallel cells always contained two or more. The latter condition was also found in the enlarged cells of the pileus trama, but as a rule the cells of the gill-trama and especially those of the subhymenium were found to be uninucleate.

The single nucleus in the young basidium enlarges, keeping pace with the developing basidium (PLATE 37, FIG. 3), and finally can be found as a large and conspicuous structure just below the apex. In this stage it resembles the large fusion nucleus found in the species previously discussed. The spireme threads, however, are not coarse and their behavior prior to the single division at the apex of the basidium is not characteristic of meiosis. The large nucleus may or may not migrate up to the apex of the basidium to divide. The division figure is rather large in this species and the centrosomes are conspicuous. Here as in *Mycena metata,* the figure is formed within the old nuclear membrane. The daughter nuceli are at first very small, but enlarge rapidly as they migrate toward the base of the basidium.

The daughter nuclei stop when they have passed slightly back of the midpoint of the basidium, and at this time two sterigmata begin to develop. As the spores increase in size, the nuclei migrate upward, and as the latter approach the sterigmata they begin to elongate, assuming the beaked condition. The centrosome is visible as a darkly staining granule at the apex of the beak. One nucleus migrates into each spore. While passing through the sterigmata the fine chromatin network becomes drawn out into long strands, but is always visible in well fixed material. The two nuclei do not always migrate simultaneously but figures have been found with a nucleus present in each sterigma. As a rule, after the migration downward, one nucleus comes to rest a little below the other and remains a little behind on its migration into the spore.

Although no clearly defined division figures were found in the sterigmata, the presence of residual nuclei in the collapsing basidia

indicate that a division must have occurred. Such nuclei were usually present in *Mycena alcalina, M. cholea, M. rubromarginata,* var. *Laricis, M. roseipallens,* and *M. vitilis.* They were uncommon in *Mycena megaspora* and *M. capillaris,* and absent in *M. lasiosperma.* In *M. cholea* (PLATE 37, FIG. 16) a basidium is shown with both spores attached, each with a nucleus, and two remaining residual nuclei in the basidium. Since no basidia with four nuclei present before migration have been found in this species, the situation shown in figure 16 must have been brought about by a division when the nuclei were migrating into the spores. In *M. lasiosperma* (PLATE 37, FIG. 26) the nucleus is shown dividing after it has migrated into the spore. The migration figures (PLATE 37, FIGS. 19, 34) of *M. lasiosperma* and *M. roseipallens* are interesting. In these species the nuclear reticulum does not show any affinity for the stain and appears to be made up of a fine, hyaline, granular network. The nucleolus appears as a large opaque structure which holds the stain tenaciously, and may be mistaken for the nucleus in poorly stained preparations. During the migration of the nucleus the nucleolus becomes beaked in a characteristic manner within the nucleus and migrates within the latter into the spore. In a majority of the species studied the reticulum is characterized by the presence of darkly staining chromatin granules, and the nucleolus does not migrate into the spore as a distinct unit.

The parthenogenetic forms producing two-, three- and four-spored basidia: Since *Mycena polygramma* var. *albida* lends itself well to cytological investigation, it will be treated in detail here. The behavior of the nuclei corresponds exactly with that of the haploid parthenogenetic forms previously discussed until they are on their way into the spores. The sterigmata begin to form at about the time the two daughter nuclei cease their downward migration. As the sterigmata develop the nuclei begin to move upward toward the apex, but, after moving a short distance, each develops a long beak which stretches out, in some instances at least, almost into a filament. The apex of the beak may come to rest somewhere near the base of a sterigma or may actually enter one. Apparently the remainder of the nucleus is now drawn upward, and the beak becomes shorter and shorter. At this time

two, three, or four sterigmata are usually well developed and a spore is forming on each. When only two sterigmata are formed the nuclei do not necessarily come to rest at the apex of the basidium, but may migrate into the spore in the usual manner. Occasional residual nuclei in collapsing two-spored basidia, however, indicate that a division sometimes takes place during the migration. If three sterigmata are formed, either one of two things may happen. Occasionally the two nuclei migrate, each into a spore, leaving the third spore without a nucleus. Rather conclusive evidence of this type of behavior was found (PLATE 38, FIG. 21). In most cases, however, the three-spored basidia produce spores with one nucleus in each. This is brought about in the following manner. One nucleus rounds up near the base of a sterigma and undergoes a division, one pole lying just below one sterigma and the other pole near or under a second. As the division progresses the poles of the figure are drawn up into the sterigmata, and a U-shaped figure results (PLATE 38, FIG. 17, 18). The daughter nuclei reorganize, one in each spore. The second nucleus may also round up, but was never seen to divide in a three-spored basidium. It usually migrates just before or with the daughter nuclei resulting from the division of the first nucleus.

If the basidium produces four sterigmata, three things may happen. First, each spore may receive one nucleus. This is commonly the case and is brought about in the following manner. Each of the two nuclei which have migrated from the base of the basidium round up somewhere near the base of a sterigma. In this position each nucleus undergoes a division, the poles coming to lie under the sterigmata, and during the anaphase the unorganized nuclei begin to migrate, forming characteristic U-shaped figures. The daughter nuclei reorganize as soon as they have moved into their respective spores. The U-shaped figures were always found in pairs and there was no indication that two nuclei ever migrated into a single spore.

Secondly, one nucleus may migrate directly into one spore while the other divides in the manner described above. Thus three spores would be found with nuclei while the fourth would be without one. One basidium (PLATE 38, FIG. 29) was found indicating this.

Lastly, the two nuclei at the base of the basidium may migrate directly, one into each of two spores, thus leaving two spores without nuclei. No evidence for this type of behavior was found.

Mycena leptocephala, M. citrinomarginata, and *M. dissiliens* all exhibit this same general type of behavior. The very minute nuclei in *M. dissiliens* make it a rather unfavorable subject for study, but typical stages were found. The spores become detached from the sterigmata of *M. citrinomarginata,* and *M. leptocephala* very easily, thus making it impossible to follow the migration of the nuclei. Collection 32–597 of *M. citrinomarginata* was found to be parthenogenetic and predominantly four-spored. The nuclear behavior was similar to that described above.

GENERAL CONSIDERATIONS

In the present investigation it has been shown that in nature fruiting bodies with two-spored basidia occur along with fruitbodies bearing four-spored basidia, and that the only differences between the two are the number of spores born on a basidium and a correlated change in spore size. In certain species it has been found that these differences occur in a single pileus as well as in pilei from different localities, and at times a cytological study must be made to determine whether a form is typical or not. Such forms are clearly segregates of four-spored species. In other species the two-spored forms are more infrequent and are separated geographically from the normal form. The close similarity in all of the characters except those mentioned above, however, indicates that these also are segregates from typical forms. Thus the majority of the two-spored forms collected can reasonably be considered as segregates of the typical forms, and it is reasonable to assume that in such isolated two-spored species as *Mycena margaritispora* and *M. lasiosperma* we may be dealing with the segregated forms of otherwise unknown species. It is possible that some of these isolated two-spored species may be stable forms which have persisted while the ancestral forms have been lost in the course of evolution. It is probable that a similar relationship exists for the two-spored forms in other genera of the Agaricaceae.

As has been previously stated, the two spored character has been

used as a diagnostic character for the separation of taxonomic units. Sass (**21**) has suggested that the term "forma" be used "in clear cut cases." Such a designation, however, would, besides being somewhat cumbersome, give undue emphasis to the two-spored condition. For instance, if a species was found to have two-spored forms of both the "*M. metata*" and "*M. megaspora*" type, they would all be classed as *forma bispora* in spite of the difference in the behavior of the nuclei in their basidia. The writer prefers to simply speak of the segregates as forms without assigning a name to them. By so doing no implication is made concerning the relationships of one form to the other except that both are segregates of the species to which they have been assigned. In species like *M. polygramma* var. *albida* or *M. citrinomarginata* where, without a cytological examination, it is impossible to ascertain with certainty whether or not one has parthenogenetic or normal fruiting bodies, a form name would serve no purpose.

The two-spored condition also results in a change in spore size which is of importance in the differentiation of taxonomic units. The writer's observations cover a sufficiently large number of species to give a fair idea of the frequency with which the change to the two-, or three-spored condition is accompanied by an increase in spore size, the amount of this change, and its bearing on the value of spore size as a character of major taxonomic importance.

As has been shown in table 1, the larger spore size was a constant feature of the variant forms, but it seems to depend upon the species whether the shape is similar or different. Thus it is possible to predict that in the genus *Mycena*, as two-spored forms are found, the spores will measure larger than those of the typical forms. No prediction is justified, however, concerning the shape of the spore. Since this situation exists, the writer feels that the differences in the basidia and spores of variant forms, particularly in the genus *Mycena*, should not be used as a basis for establishing species. In typical forms, however, spore size and shape are remarkably constant and useful in separating species within the genus.

Since the basidia of two- and four-spored forms seem to be

approximately the same size, the question arises as to whether or not within a species, the volume of the two spores produced on a single basidium is equal to the volume of the four spores also from a single basidium. The shape of the spores of two species is such that rough approximations of their volumes can be easily made. In *M. capillaris* and *M. citrinomarginata* the spores are roughly cylindrical in shape. The following approximations may be made:

M. capillaris (4-spored) 143.3 cu. microns per spore
573 total volume of 4 spores.
M. capillaris (2-spored) 285 cu. microns per spore
570 total volume of *2* spores.
M. citrinomarginata (4-spored) 196.6 cu. microns per spore
786 cu. microns total volume of 4 spores.
M. citrinomarginata (3-spored) 255.2 cu. microns per spore
765 cu. microns total volume of 4 spores.

While only approximations, these figures indicate that there is little if any change in the volume of material used in the formation of the spores in the correlated forms, and that the difference in spore-size may possibly be explained on the basis of the amount of material available for spore formation. One would expect the above ratio to be rather constant in forms producing both two- and four-spored basidia on a single pileus. The variation in size of basidia and spores of geographical races might be sufficient to overbalance this difference if the two-spored form from one locality is compared with a four-spored form from a different locality.

In the species of *Mycena* investigated in this study the basidia were always emptied of protoplasm before the spores were shed. If this does not happen, however, it is doubtful if there would be an increase in spore size to the extent described above. In other genera the basidia of the variant forms are not always emptied of protoplasm as completely as in *Mycena* and in such cases it is not likely that an equal increase in spore size would be found in the variant forms. *Naucoria semiorbicularis* f. *bispora* Sass (21) seems to be an example.

CYTOLOGICAL CONSIDERATIONS

The typical forms: The nuclear behavior in eight of the four-spored species agrees with that found in *M. galericulata* as described by Maire (**17**) except that the spores are usually uninucleate. The occasional binucleate spores which were found may have obtained their nuclei either by the division of the nucleus after entering the spore, or by the migration into the spore of the daughter nuclei resulting from a third division.

Wager (**22**) figured two reorganized nuclei resulting from the first division in *Mycena galericulata*. Wakayama (**23**) in his studies of a large number of agarics in various genera found that in *Mycena haematopoda* the daughter nuclei of the first division always reorganize before undergoing the second. In species of other genera, he found no period of interkinesis. All of the forms studied by the writer exhibiting meiosis also show a similar short period of interkinesis between the first and second divisions.

Evidence of the regular occurrence of a third division in the basidium has been found in all of the typically four-spored species investigated and may well be considered typical for the genus. It has been shown that this division is postponed until the nuclei are starting to migrate or are actually migrating into the spores. It is thus definitely removed from the meiotic divisions in time as well as location. In the species of *Craterellus* and *Clavaria* which have been studied (**8**) the third division may either follow soon after the first two, and before the nuclei have begun to migrate, or take place in the basidium after the spores are partly formed.

Two-spored forms of the *Mycena metata* group: The third division which was found to be characteristic of the four-spored forms is also present in the group of two-spored forms characterized by *Mycena mètata*. In this group we find a situation essentially similar to that found by Sass (**21**) in the two-spored form of *Coprinus ephemerus*. Two nuclei regularly migrate into each spore. Because attempts to germinate the spores in this group of species have been unsatisfactory, it has been impossible to determine whether they are "heterothallic" or "homothallic." Since their nuclear history is essentially like that of the two-spored form of *C. ephemerus*, however, one would expect them to be "homothallic."

In this group the fusion nucleus gives rise to four daughter nuclei. One of the daughter nuclei migrates into each spore where it divides. The remaining two nuclei may divide in the sterigmata or after entering their respective spores. If the division takes place before entrance, one would expect to find residual nuclei in the basidium. If it takes place after the nucleus enters the spore, the basidium should be empty. Division figures have been found in the spores and sterigmata of most of the species in this group. Both empty basidia and those with residual nuclei have also been found.

Since both Sass and Buhr have interpreted the residual nuclei which they observed in the collapsing basidia of the forms they studied as remains of two of the original four nuclei produced by the two meiotic divisions, their descriptions and figures should be reconsidered in the light of the above facts. In the two species of *Mycena* which Buhr studied, the residual nuclei could have originated in either manner. The basidia shown in his figures do not have the spores attached. In *Nolanea cetrata,* however, his illustrations are convincing enough. The attached spores (FIG. 11) each have a nucleus and two have remained in the basidium. In *Psalliota campestris* (FIG. 24) the residual nuclei show their usual structure as do those of *Pholiota erebia* (FIG. 4). Sass (**21**), plate 66, figures 60 and 61 of *Naucoria semiorbicularis,* illustrates the residual nuclei as possessing their normal structure, while on plate 67, fig. 73 the one residual nucleus shown for *Galera tenera* is opaque.

In all of the writer's slides the residual nuclei stained very darkly, similar to the telophases of the earlier divisions, and were never found to reorganize sufficiently to show either a reticulum or nucleolus. Buhr's (**4**) figures 36 and 37 of *Mycena debilis* certainly illustrate a condition closely approaching this. It is quite possible that the residual nuclei originate differently in different species or genera. Certainly if two of the original four nuclei disintegrate, one would expect to find early stages in which the structure of the nucleus was still visible. If, on the other hand, the nuclei left in the basidium by the third division degenerate without reorganizing, no such early stages could be expected.

The omission of a division in the parthenogenetic forms studied

by the writer is interesting because it furnishes still more evidence in support of the statement that three divisions are characteristic in the basidia of this genus. In both the typical forms and those of the *M. metata* type two divisions in the apex of the basidium are characteristic before the sterigmata begin to form. In the parthenogenetic forms only one such division occurs. Thus it is reasonable to assume that the reduction divisions are omitted and in their place a single mitosis occurs. This is apparently the same situation which Bauch (1) disscovered in *Camarophyllus virgineus*. In the two-spored form of that species Bauch found that one of the two nuclei resulting from the single division at the apex of the basidium migrated into each spore. In the parthenogenetic forms studied by the writer two divisions were characteristic, the second, however, corresponded closely in both time and irregularity of occurrence to the third division found in the typical forms and in the variants of the *M. metata* type. It is no doubt homologous with it.

The manner in which the last division functions in the distribution of nuclei to the various spores of the forms producing two, three and four sterigmata is interesting. As a result of it, it is possible to have four-spored forms in the genus *Mycena* which are indistinguishable unless the material is examined cytologically. Such forms have been collected. No particular significance can be attached to the spores which do not receive nuclei, but it would be interesting to determine their approximate percentage and whether or not they are discharged from the basidium in the usual way. Since two-spored forms of both cytological types are common in a single genus it is apparent that the nuclear history is not necessarily concerned with the number of sterigmata produced on a basidium. In the *M. metata* type the behavior of the nuclei is typical, but the basidia are constantly two-spored. In the *M. megaspora* type the nuclear behavior varies but the number of sterigmata may be four. That the two-spored condition is a constant genetical character in the forms of the *M. metata* type is borne out to some extent at least by the fact that the forms of this group can be collected year after year in the same as well as in widely scattered localities under a variety of weather conditions. The parthenogenetic series, however, does not present a clear cut

case because of the numerous specimens producing two, three, and four spores on different basidia in a single pileus.

The results of the present investigation when considered in the light of previously known facts indicate that in a closely related group as well as in a group of distantly related forms, the same types of variation in the nuclear behavior are encountered. Buhr (**4**), summarizing the information concerning two-spored forms in the Hymenomycetes, lists sixteen species having a normal fusion with the customary two divisions following (except in the species of *Clavaria* and *Craterellus* which have a third). In contrast to this, only two are listed definitely as being parthenogenetic. He includes two species of *Mycena* in the first group and one in the second. The results of this investigation add seven species of *Mycena* to the former group, twelve to the latter, and prove conclusively that the parthenogenetic type of variant is common in the genus.

The forms and species showing a reduction in the number of spores born on the basidium presents an interesting series in the Hymenomycetes. Species of Clavariaceae and Cantharellae are known to have basidia bearing more than four spores and also to have two-spored forms. In the Agaricaceae, four sterigmata are usually formed. Parthenogenetic four-spored forms as well as those varying between the two- and four-spored condition are known in *Mycena.* In *Galera,* Bresadola (**3**) has figured a form of *G. silignea* with monosporous basidia. In *Naucoria lenticeps* Peck, fruiting bodies bearing basidia with one, two, three or four sterigmata have been found by the writer. Thus within a single species or in the group as a whole variations of from one to four spores are known to occur.

The presence of a third division in most of the basidia of typical and variant forms of *Mycena* supports the hypothesis that the species of this genus are rather closely related to primitive types which are characterized by three successive nuclear divisions in the basidium. The variations found indicate that the character is in a transitional state.

SUMMARY

1. During the course of the present investigation sixty-five typical and twenty-seven variant forms were collected.

2. One species *Mycena cholea* and one variety *Mycena rubromarginata* var. *Laricis* are described as new.

3. Of the twenty-seven variant forms collected, fourteen have been correlated with typical forms.

4. An increase in spore size has been found to accompany the change to the two- or three-spored condition. A change in spore shape may or may not accompany the change in the number of spores born on a basidium.

5. The writer believes that the variations in spore size and shape noted for the variant forms should not be used as basic distinctions in describing new species.

6. Nine typically four-spored forms have been studied cytologically. In eight, *M. Atkinsoni, M. alcalina, M. hemisphaerica, M. haematopoda, M. leptocephala, M. sanguinolenta, M. stannea* and *M. viscosa* the nuclear history is characterized by a fusion of two primary nuclei followed by two meiotic divisions, and a third division before the nuclei migrate into the spores. Four nuclei usually degenerate in each basidium. In *Mycena murina* there is a similar third division, but each spore receives two nuclei.

7. Of the variant forms studied, *M. metata, M. clavicularis, M. graveolens, M. immaculata, M. margaritispora, M. mirata,* and *M. viscosa* all possess two primary nuclei which fuse. Three divisions were found to be characteristic, but the third was rather haphazard, occurring either in the spores or basidia. *M. megaspora, M. alcalina, M. capillaris, M. cholea, M. citrinomarginata, M. dissiliens, M. lasiosperma, M. leptocephala, M. polygramma* var. *albida, M. roseipallens, M. rubromarginata* var. *Laricis,* and *M. vitilis* were found to have a single nucleus in the young basidium and are considered to be parthenogenetic. Instead of the usual three divisions found in the other forms in this genus, the parthenogenetic forms were characterized by two, the last of which is apparently homologous with the third division found in the other types.

8. Four of the parthenogenetic forms, *M. citrinomarginata, M. dissiliens, M. leptocephala* and *M. polygramma* var. *albida* were found to produce two, three, or four spores on different basidia of a single pileus. In these forms the transverse arrangement of the spindles in the second division was found to form a mechanism whereby a nucleus was usually distributed to each spore. The

process, however, was found to be rather variable and spores without nuclei were found. The latter condition may be brought about by a nucleus failing to undergo the last division before migration, or possibly by the longitudinal instead of the transverse arrangement of the second division spindle.

9. Since both the *M. metata* and *M. megaspora* types of variants are common in *Mycena*, it seems improbable that the nuclear behavior in the basidium is in any way connected with the number of spores produced on a basidium.

EXPLANATION OF PLATES

PLATE 34

The drawings were made with the aid of a camera lucida using a Bausch & Lomb 3 mm. N. A. 0.85 objective and a 25 × ocular. As reproduced, the magnification is approximately 830 ×.

Fig. 1, Spores of four-spored form of *Mycena epipterygia.*
Fig. 2, Spores of two-spored form of *Mycena epipterygia.*
Fig. 3, Spores of two-spored form of *Mycena alcalina.*
Fig. 7, Spores of four-spored form of *Mycena alcalina.*
Fig. 4, Spores of two-spored form of *Mycena capillaris.*
Fig. 5, Spores of four-spored form of *Mycena capillaris.*
Fig. 6, Spores of two-spored form of *Mycena roseipallens.*
Fig. 9, Spores of four-spored form of *Mycena roseipallens.*
Fig. 8, Spores of four-spored form of *Mycena viscosa.*
Fig. 11, Spores of two-spored form of *Mycena viscosa.*
Fig. 10, Spores of two-spored form of *Mycena lactea.*
Fig. 13, Spores of four-spored form of *Mycena lactea.*
Fig. 12, Spores of four-spored form of *Mycena immaculata.*
Fig. 14, Spores of two-spored form of *Mycena immaculata.*
Fig. 15, Spores of four-spored form of *Mycena metata.*
Fig. 16, Spores of two-spored form of *Mycena metata.*
Fig. 17, Spores of three-spored form of *Mycena citrinomarginata.*
Fig. 18, Spores of four-spored form of *Mycena citrinomarginata.*
Fig. 19, Spores of two-spored form of *Mycena mirata.*

PLATES 35–38 INC.

The drawings were made with the aid of a camera lucida using a Zeiss 2 mm. N. A. 1.3 apochromatic objective and a 20 × compensating ocular. All are reproduced at a magnification of approximately 1100 ×.

PLATE 35

Fig. 1–10 inc. *Mycena Atkinsoni.* 1, a young basidium showing two primary nuclei; 2, the fusion nucleus; 3, a metaphase stage of the first division; 4, reorganized nuclei after first division; 5, telophase of second division; 6,

four reorganized daughter nuclei; 7, four nuclei near the center of the basidium before the spores have begun to form; 8, four spores, each with a nucleus, and four residual nuclei in the basidium; 9, telophase of third division; 10, old basidium with four residual nuclei.

Fig. 11–26 and 29–32 inc. *Mycena murina.* 11, young basidium with two nuclei; 12, fusion nucleus; 13, first division; 14, two of the four daughter nuclei which have migrated up from near the base of the basidium in preparation for the third division; 15, four daughter nuclei in the upper part of the basidium a short time after the second division; 16, four nuclei in the lower part of the basidium; 17, telophase stages of the third division, the spores were no doubt broken off; 18, two reorganized nuclei after the first division; 19, telophase stages of second division; 20, metaphase stages of third division, spindles arranged transversely; 21, metaphase stages of third division, spindles arranged longitudinally; 22, three spores with one nucleus each and one nucleus in each of the four sterigmata; 23, metaphase figure of third division, spindle arranged transversely; 24, telophase of third division; 25, one nucleus about to enter a spore and a second dividing at the base of the sterigma; 26, two nuclei in each of four sterigmata; 29, three spores each with a nucleus, and a second nucleus about to enter each spore; 30 and 31, the same basidium, each of the four spores contains two nuclei and the basidium is empty; 32, portion of a basidium showing one spore with a nucleus and a second nucleus dividing transversely at the base of the sterigma (32 and 24 are of the same basidium but at different focal planes).

Fig. 27, 28 and 35, *Mycena viscosa,* four-spored. 27, metaphase of third division, the spores have probably been broken off; 28, telophase of third division; 35, three spores with nuclei, four residual nuclei in the basidium.

Fig. 33, 34, 36, 37, 38, *Mycena hemisphaerica.* 33, third division figures; 34, spores with dividing nuclei, the spores had been broken from their attachment; 36, basidium with four spores each with a nucleus, four residual nuclei in the basidium; 37 and 38, four residual nuclei in each of two old basidia.

Fig. 39–43 inc. *Mycena metata,* two-spored. 39, young basidium with two primary nuclei; 40, fusion nucleus; 41, anaphase of first division; 42, telophase of first division; 43, reorganized nuclei from first division.

PLATE 36

Fig. 1–10 and 12, *Mycena metata,* two-spored. 1, metaphase of second division; 2, telophase of second division; 3, a basidium with four nuclei, two spores are shown in an early stage of development; 4, a basidium with no residual nuclei, one nucleus at the base on one spore shown dividing while the nucleus at the apex is in the resting condition, in the other spore the nucleus at the apex is dividing, it can not be definitely determined whether the nucleus at the base of the second spore had just entered or whether it also was dividing; 5, two nuclei in the sterigmata and one in a spore dividing simultaneously; 6, one nucleus dividing in a sterigma and one in the apex of the spore, in the second spore both nuclei are in the resting state; 7, two nuclei dividing in one spore, two resting nuclei in the other, there are no residual nuclei in the basidium; 8, one spore with three nuclei, one spore with one nucleus (in the telophase stage) and two nuclei in the basidium; 9, a spore with

four nuclei; 10, a spore with two nuclei dividing and no residual nuclei in the basidium; 12, a collapsing basidium with two residual nuclei.

Fig. 13–15, *Mycena stannea*, four-spored. 13, four nuclei beaked, the centrosome is at the apex of the beak; 14, daughter nuclei of the third division; 15, a portion of an old basidium showing two spores, the small basidium shows two primary nuclei.

Fig. 11, 16–21 and 23, *Mycena margaritispora*. 11, a spore with four nuclei; 16, a basidium with two primary nuclei; 17, first division, spindle arranged transversely; 18, second division; 19, third division (in spores and sterigmata); 20, four residual nuclei in an old basidium; 21, two residual nuclei in an old basidium; 23, first division, spindle arranged longitudinally.

Fig. 24–27, and 29, *Mycena viscosa*, two-spored. 24, basidium with two primary nuclei; 25, second division, one spindle longitudinal and the other nearly transverse and viewed from the metaphase plate; 26, four nuclei in the lower portion of the basidium; 27, nuclei elongating preparatory to passing through the sterigmata; 29, an empty basidium with two spores each with two nuclei (all of the nuclei are seen to be practically in the same stage of division).

Fig. 22, *Mycena sanguinolenta*, an old basidium showing residual nuclei and two spores each with a nucleus. Two sterigmata were apparently removed in sectioning.

Fig. 30, 31, 38, and 39, *Mycena mirata*. 30, young basidium with two primary nuclei; 31, four nuclei in a basidium at the time the sterigmata are forming; 38 and 39, old basidia, one showing residual nuclei.

Fig. 35 and 36, *Mycena clavicularis*, two-spored. 35, young basidium with primary nuclei; 36, basidium with four nuclei shortly after the second division.

Fig. 37 and 44, *Mycena immaculata*, two-spored. 37, basidium with two primary nuclei; 44, four nuclei at about the time the spores start to form.

Fig. 32, 33, 40–43, *Mycena graveolens*, two-spored. 32, young basidium with two primary nuclei; 33, a spore with four nuclei; 40, basidium with four nuclei; 41, a basidium with two spores attached, each with three nuclei (it is possible that one nucleus divided while in the sterigma and that the other migrated without dividing. The pairs of nuclei at the apex are interpreted as daughter nuclei resulting from a division in the spore); 42, an old basidium with two residual nuclei; 43, an old basidium with four residual nuclei.

PLATE 37

Fig. 1–10 inc. *Mycena megaspora*. 1, young basidium with a single nucleus; 2, young basidium and subhymenial cells with one nucleus each; 3, a developing basidium with its enlarging nucleus; 4, a metaphase stage of the only division which takes place near the apex of the basidium before the sterigmata begin to form; 5, telophase stage; 6, the enlarging basidium with the two reorganized nuclei; 7, an early stage in the formation of the sterigmata; 8, the two nuclei in the basidium have started to migrate, the spores are still very small; 9, a nucleus partly in the spore and partly in the sterigma; 10, one nucleus is seen in each spore, the basidium contains no residual nuclei.

Fig. 11, 12 and 19, *Mycena roseipallens.* 11, the young basidium with its single nucleus; 12, and 19, the nuclei are shown partly elongated, the nucleolus is also shown migrating as a distinct body within the nucleus.

Fig. 13 and 14, *Mycena rubromarginata* var. *Laricis.* 13, young basidium and basal cell each with one nucleus; 14, two nuclei each migrating into its respective spore.

Fig. 16, 17, 23, *Mycena cholea.* 23, young basidium with a single nucleus; 17, basidium with two nuclei at about the time that the spores begin to form; 16, old basidium with two spores attached, each with a nucleus and two residual nuclei in the basidium indicating that a division must have taken place during migration.

Fig. 15, 22, *Mycena capillaris,* two-spored. 15, the nuclei are elongating preparatory to passing through the sterigmata; 22, young basidium with a single nucleus.

Fig. 20, 21, 26, 27, and 34, *Mycena lasiosperma.* 20, young basidium with a single nucleus; 21, division at apex of basidium; 26, spore showing nucleus in telophase stage; 27, portion of a basidium showing how the nucleolus elongates with the nucleus; 34, nuclei elongating preparatory to entering the spores.

Fig. 18, 24, *Mycena vitilis.* 18, basidium with spore beginning to form; 24, young basidium with a single nucleus.

Fig. 28, 30, 31, 36–38, *Mycena leptocephala,* parthenogenetic form. 28, young basidia and subhymenial cell showing a single nucleus each; 30, a basidium with two sterigmata beginning to form and two nuclei slightly elongated; 31, nucleus dividing at base of sterigmata; 36, young basidium with a single nucleus; 37, the enlarged nucleus prior to dividing; 38, four sterigmata forming on one basidium and only two nuclei in the basidium.

Fig. 35, 42, 43, *Mycena citrinomarginata,* parthenogenetic form. 35, nuclear division at the base of the sterigmata; 42, nuclear division at the apex of the basidium before the spores have begun to form; 43, a basidium with two nuclei and two sterigmata.

Fig. 32, 33, 39, 40, 41, *Mycena dissiliens,* parthenogenetic form. 32, young basidium and basal cell each with a single nucleus; 33, the single division at the apex of the basidium; 39, the two daughter nuclei after they have moved downward; 40, the nuclei near the base of the basidium becoming beaked (note the three sterigmata which are nearly formed); 41, telophase of the division at the base of the sterigma.

PLATE 38

Fig. 1–29, *Mycena polygramma* var. *albida,* parthenogenetic form. All of the figures were drawn from the basidia of a single pileus. 1–7, illustrate the usual type of development in parthenogenetic forms; 8–10, illustrate basidia each with two nuclei, but two, three, and four sterigmata; 11–13, show nuclear elongation in two-spored basidia; 14, the two nuclei have assumed a position which indicates that migration has ceased temporarily (the stage shown in fig. 11 precedes this one); 15–18, portions of basidia showing the division at the bases of the sterigmata; 19–20, nuclear migration in two-spored basidia; 21, a basidium which produced three spores, but in which

both nuclei migrated without dividing thus one spore did not receive a nucleus; *22*, a basidium showing two nearly mature spores and one partly developed, the origin of the single nucleus in the basidium can not be definitely determined; *23–24*, three-spored basidia, each spore receiving a nucleus; *25*, a three-spored basidium; each spore with a nucleus; *26*, two nuclei in a basidium and four spores forming; *27*, each nucleus divides, and thus each spore receives a nucleus; *28*, a basidium with four mature spores, each with a nucleus; *29*, a four-spored basidium in which only three spores received nuclei.

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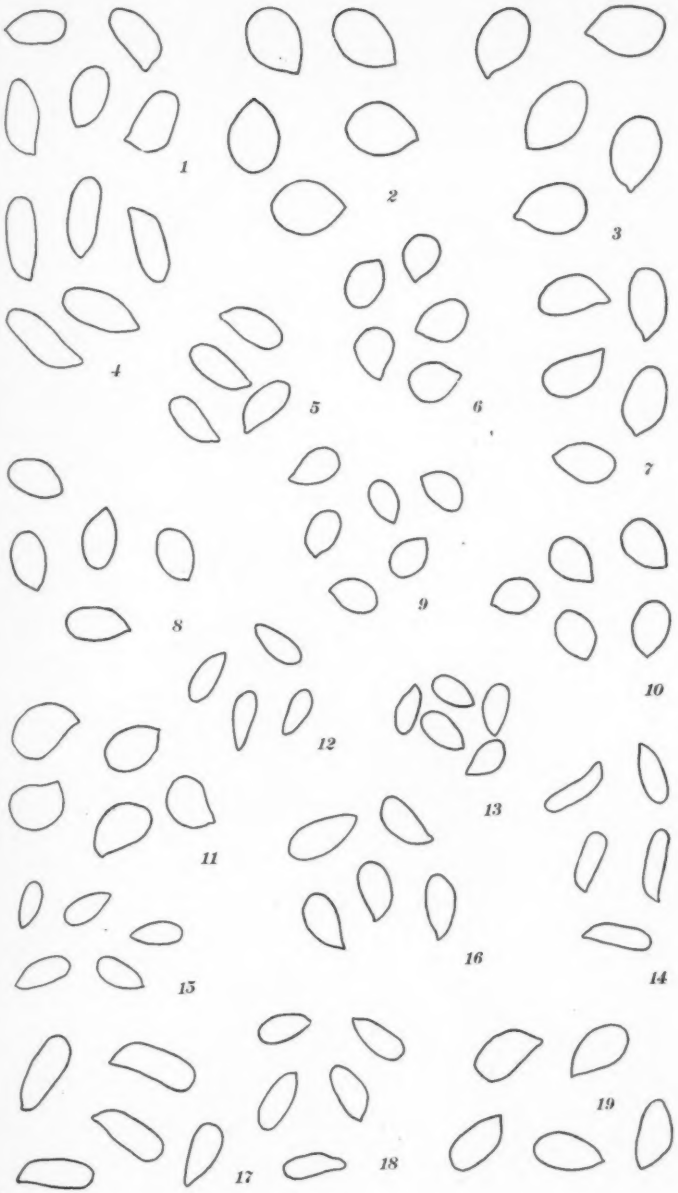

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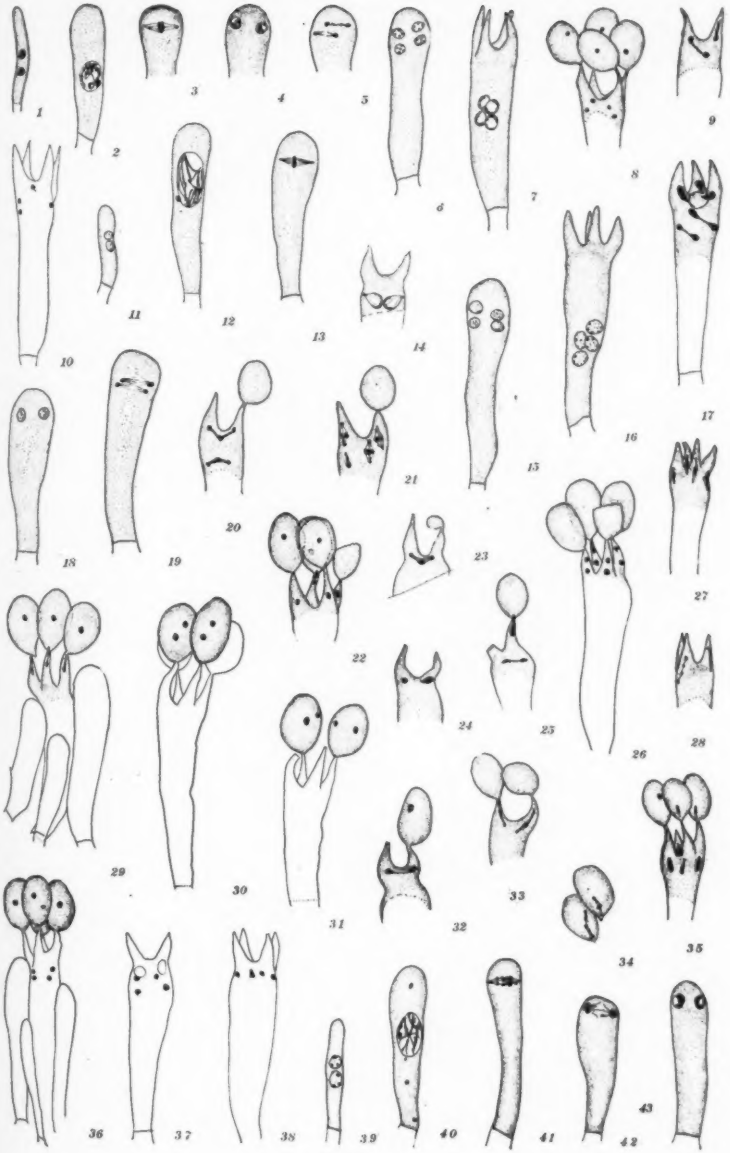

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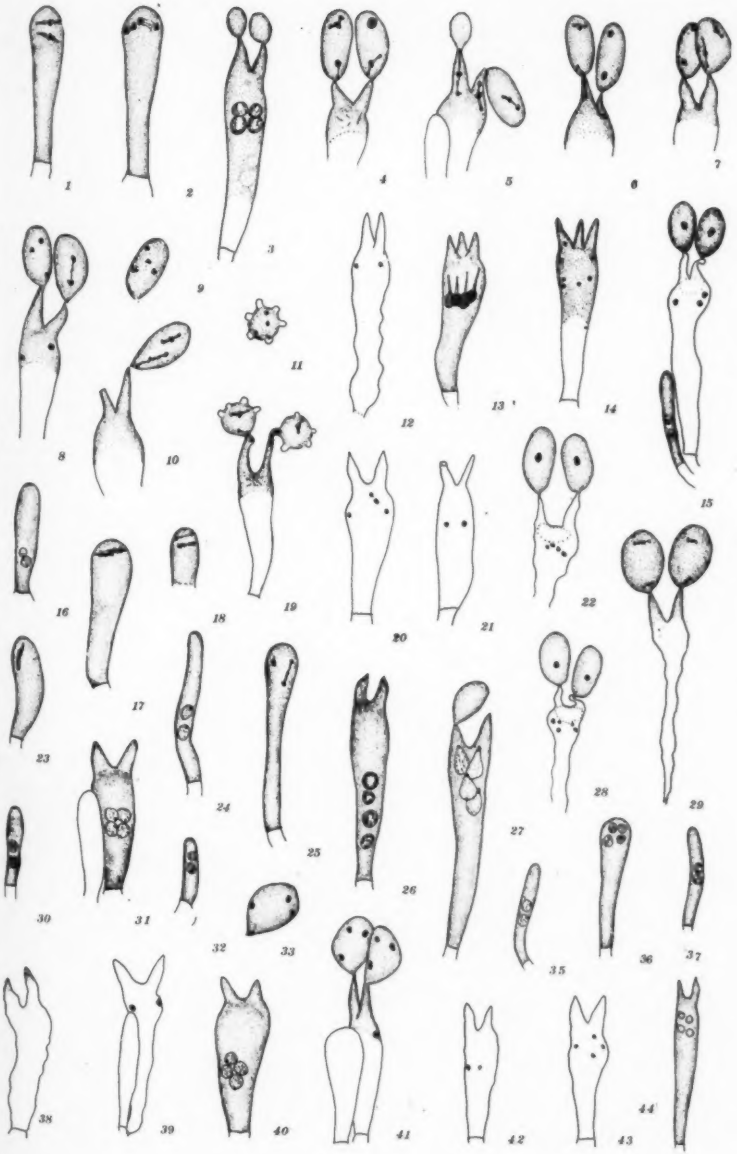

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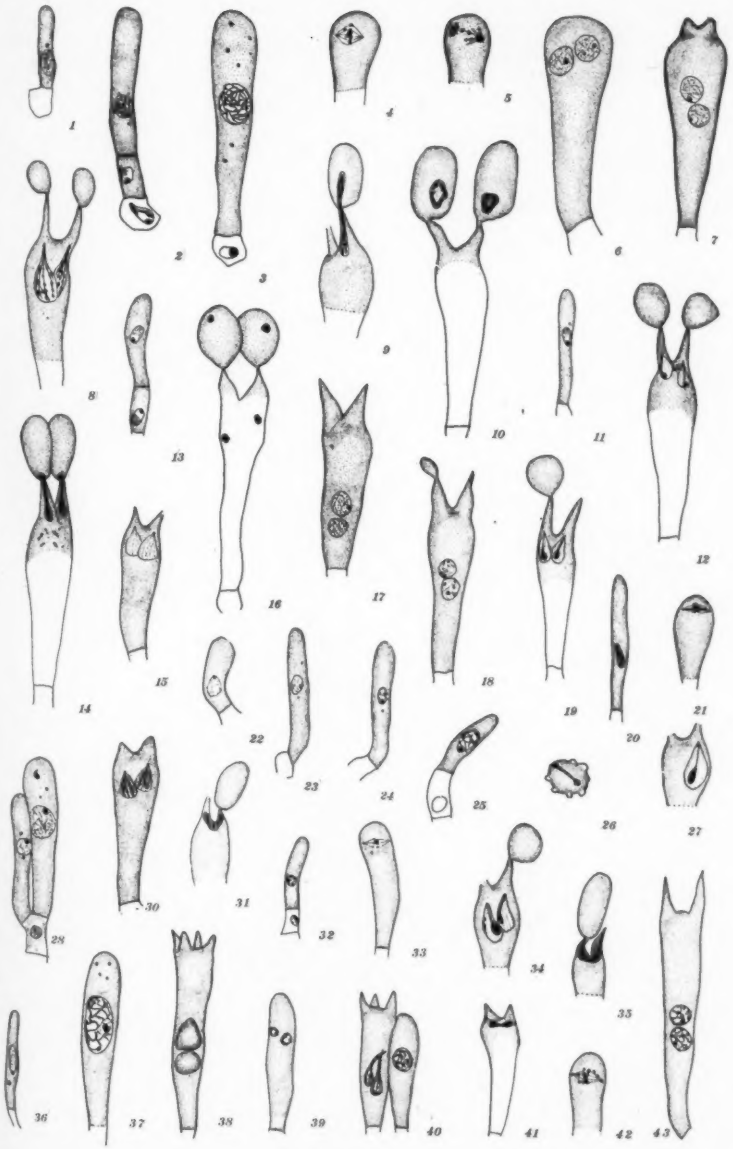

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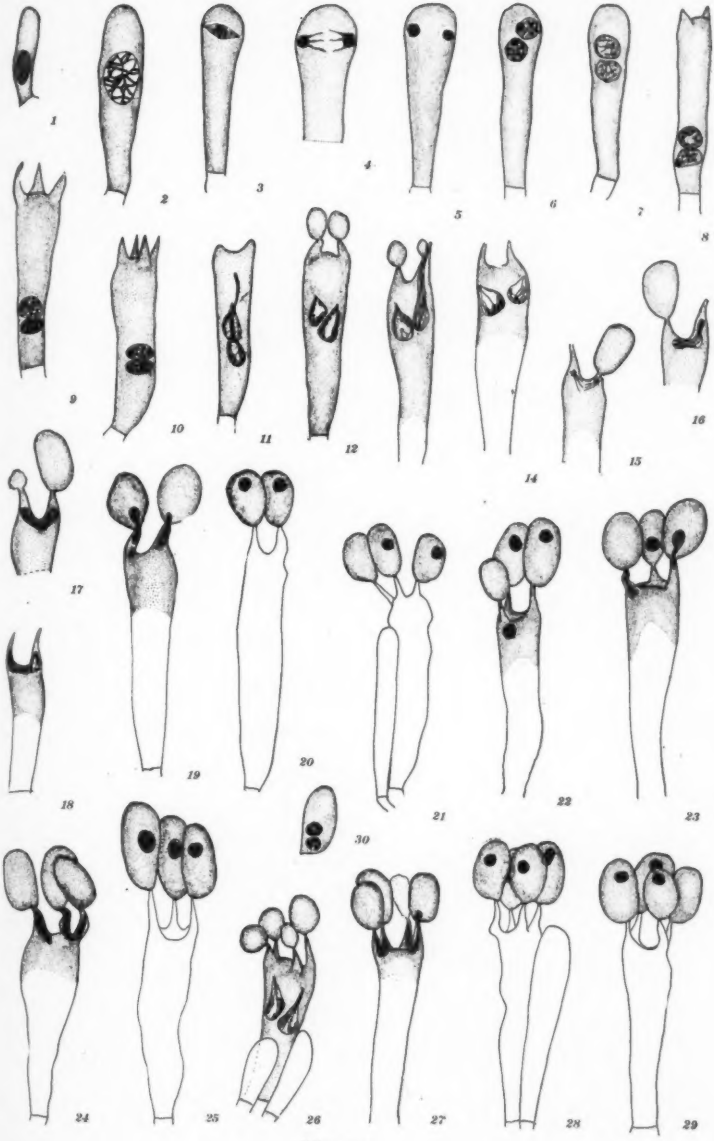

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THE GENUS MYXOMYCIDIUM [1]

DAVID H. LINDER

(WITH PLATE 39 AND 1 TEXT FIG.)

The genus *Myxomycidium* was first described by Massee (**4**) from material sent to him from Tasmania by Rodway with the notation "Always pendulous and in consistency much more watery than any *Clavaria* we have." Doubt as to the position of the genus was expressed by Massee when he wrote "A remarkable genus without very evident affinities. The watery, gelatinous substance suggests the Tremellineae, but the narrowly clavate basidia, surmounted by four slender sterigmata, are opposed to this view. The general form of the sporophore is that of the Clavariae, where the gelatinous consistency is unknown." These remarks would indicate that he believed the organism to be more closely related to the Clavariaceae than to the Tremellineae, but Killermann (**2**) places it among the doubtful genera of the Tremellales.

In view of the apparent rarity and of the uncertainty concerning the taxonomic position of the genus, it seems worth while to record the observations made by the writer on material collected in British Guiana, South America, in 1923. The material unfortunately was preserved in 4 per cent formaldehyde solution and therefore was not in the best condition for cytological study. Nevertheless, by choosing those basidia which showed the nuclear structure and position most clearly, a fairly good idea of nuclear behavior could be obtained. The preparations were made by crushing under a cover glass the material mounted in lactophenol-cotton-blue and picric nigrosin, or in lactophenol plus equal parts of cotton blue and safranin Y. However, in spite of the care taken in working out nuclear behavior, it is evident that the results cannot be accepted as conclusive until supported by the study of properly killed and fixed material.

[1] Contribution no. 127 from the Laboratories of Cryptogamic Botany of Harvard University.

The fruiting bodies (PLATE 39, FIG. 1) of the South American material were growing gregariously on the side of a moist decaying log which still retained its bark. The younger fruiting bodies appeared to be little more than a short white stipe with a firm, white, gelatinous, clavate enlargement at the apex. With increasing age, the fruiting body enlarged apically and became more watery-white and considerably softer, until finally it became so watery at maturity that it was almost impossible to touch it without it flowing around one's fingers and leaving the stipe behind. Just before this final stage of liquefaction, the fruiting body was tinged a dilute ochraceous yellow, the color apparently imparted by the numerous spores.

Longitudinal sections of the fruiting bodies, made from specimens embedded in celloidin and stained,[2] disclose the fact that the fructifications which externally appear to the naked eye to be relatively simple structures, are in reality clearly differentiated into three distinct layers except near the apex where there is a transition zone that is not so clearly marked. Beginning at the center, there is a core consisting of irregularly coiled and contorted hyphae that run lengthwise. They are derived from the closely aggregated, nearly parallel hyphae that make up the short stipe. Towards the apex, the curled and twisted hyphae of the core straighten out and radiate to form the inverted rounded-conical tip, at the surface of which the basidia are formed. These radiating hyphae of the apex of the fruiting body merge with, and are a continuation of, the hymenial and subhymenial layers that are so clearly differentiated in the broader basal part of the fructification. In this broader region the hyphae although branched and flexuous or undulate, run parallel to one another and at right angles to the axis of the core to form the loose subhymenial tissue that is 100 to 150 μ thick. Most of the cells in this zone are binucleate but none of them show any evidence of clamp connections. The ends of the hyphae of the subhymenial layer become richly branched and give rise to the third or hymenial layer, 25 to 40 μ thick, which is composed of basidia rather closely aggregated in a palisade-like layer that covers the entire periphery of the swollen part of the fruiting body.

[2] The writer wishes gratefully to acknowledge the assistance of Dr. Roy Whelden, who embedded and stained this material.

The basidia are of two types: simple and "proliferative." The simples ones, 15–23 × 4.5–7 μ, are not truly narrowly clavate as the dimensions would indicate, since the measurements are taken from the length and contrasted with the broadest part. It would be more accurate to give the shape, in outline, as spatulate since the base of the basidium is relatively narrow, 2–3 μ in diameter, and apically is inflated into a subglobose to ellipsoid head. The "proliferative" type (PLATE 39, FIG. 20, 22) consists of two parts which correspond to the hypobasidium and epibasidium of Neuhoff (**5**). The hypobasidium is formed in the same manner as the true basidium, but instead of continuing to form sterigmata, proceeds to the formation of a second basidium-like structure that actually produces the sterigmata. Both the simple basidia and the epibasidia bear four sterigmata and thus they resemble the corresponding structures of the higher Autobasidiomycetes. The hymenium of the smaller fruiting bodies is composed of a single layer of basidia, but with increasing age and as the first formed basidium reaches maturity, a side branch is produced just below the basidium and this in turn gives rise to another basidium. The process is repeated until several basidia are formed at the end of a single branch of the subhymenial hyphae (PLATE 39, FIG. 24).

Nuclear behavior, so far as it can be made out from the material available, presents in the one instance a behavior similar to that found in the Tremellales, in the other, resembling that of the higher basidiomycetes. As the terminal cell begins to swell to form the basidium, the paired nuclei migrate to a central position and then as they come together, there is formed on each nucleolus a short comma-like tail that is directed obliquely towards the wall at the point of contact of the two nuclei (PLATE 39, FIG. 5), and then as the two nuclei are about to fuse, the comma-like tails are directed towards the opposite ends of the basidium (PLATE 39, FIG. 6). The fusion nucleus, it would seem, immediately enters the prophase (PLATE 39, FIGS. 7, 8) in which condition it migrates towards the apical end of the basidium which started to enlarge prior to the fusion of the nuclei and has by now reached its full dimensions. When the nucleus reaches the apex of the basidium, the chromatin material which has been in threads that were arranged around the periphery of the nucleus, breaks up or shortens into eight rather

distinct chromosomes (PLATE 39, FIG. 9) after which process the spindle is formed at right angles to the axis of the basidium (PLATE 39, FIG. 10) and division is finally completed. This appears to be the reduction division and can easily be distinguished from the later divisions, not only by the broader and more conspicuous spindles and by the more numerous chromosome masses, probably eight in the diploid phase, but also by the direction in which the process takes place.

Following the reduction division, the daughter nuclei migrate toward the base of the inflated terminal part of the basidium, and there undergo the second division. This time the process is completed, not in an horizontal direction, but at an oblique or nearly vertical direction, the direction depending in part on the angle from which the spindles are viewed. In the majority of instances they are oblique and parallel (PLATE 39, FIGS. 11–13), although in one or two instances (PLATE 39, FIGS. 14, 15) it would appear that, although dividing obliquely in reference to the axis of the basidium, the daughter nuclei divide at right angles in reference to each other. Whether this discrepancy in nuclear behavior is a result of improper fixing or whether the nuclei normally divide in an irregular fashion it is difficult to state since it is at this stage of development that the material proves rather unfavorable for cytological study. At any rate, it can be said that prior to division of the daughter nuclei or during the process, the basidium, if it is to be of the "proliferative" type, begins to send out the slender terminal elongation (PLATE 39, FIG. 11) that is later to enlarge and become the epibasidium. Apparently the epibasidium is not formed until after the completion of nuclear division since the resulting four nuclei may still be seen (PLATE 39, FIG. 15) in the hypobasidium, whence they do not migrate until formation of the sterigmata is initiated (PLATE 39, FIG. 18) and then they do not always migrate at one time, but may travel outward in pairs. The simple basidium offers little difficulty in interpretation since it appears that the nuceli merely migrate from the base of the inflated head to the apex (PLATE 39, FIG. 17), although it has been impossible to find any correlation between the position of the nuclei and sterigma formation. It is clear, however, that the nuclei in migrating from the basidium or epibasidium, as the case may be,

lose considerable volume since when they next appear in the spores they are noticeably smaller.

The subsequent history of the basidiospores remains obscure. There is, however, indication that the nucleus may divide within the spore (PLATE 39, FIG. 2) and if that is true, it is possible to postulate that the basidiospores proceed to the formation of secondary spores in a manner comparable to the repeated spore formation in the Tremellales. Further evidence for repeated spore formation is offered by the presence of large numbers of basidiospores which are entirely devoid of content. Unfortunately these spore remnants are so transparent that it is impossible to discern any evidence of sterigmata.

In addition to the basidiospores, there are present on the fruiting body larger spores of essentially the same shape, but characterized by the presence of two or more nuclei. Such spores, although abundant in two or three of the fruiting bodies, were never found attached to any definite structure, and perhaps they may prove to be of foreign origin. In only one instance was any comparable structure found without question to be attached to the hyphae of the fruiting body (PLATE 39, FIG. 4), but that was so immature that the writer hesitates to conclude that it is the same as the large several-nucleate spore, especially since obviously foreign spores are also present.

The relationship of the South American species of *Myxomycidium* is clearly not with the Tremellales in the narrower sense of the term since septa are lacking in the basidia and also because instead of both divisions of the fusion nucelus taking place in a more or less horizontal plane, as in the majority of the species of the Tremellaceae, only the first division is horizontal. There are, however, many instances in which the septa of the tremellaceous fungi are laid down irregularly instead of vertically and this would indicate that not all divisions of the nuclei are in an horizontal plane. Lack of septations in the hypobasidium, then, would prevent this species from being placed in the Tremellaceae. On the other hand, the jelly-like consistency of the fruiting body would seemingly exclude the species from the Clavariaceae even though there is present a well differentiated hymenial layer. For the sake of brevity and clarity, the differences between *Myxomycidium*

and members of the chiastobasidial Clavariaceae are tabulated below. Obviously the stichobasidial *Clavarias* need not be considered since the first division of the nucleus is parallel to the long axis of the basidium.

Myxomycidium (South American)	Clavariaceae (chiastobasidial)
Fructification soft, gelatinous.	Fructification brittle to firm, fleshy to fibrous.
All hyphae in a gelatinous matrix.	No evidence of gelatinous matrix.
Subhymenium of nearly parallel hyphae.	Subhymenium of intricately intertwined hyphae.
Basidia conspicuously inflated at the apex.	Basidia mostly narrowly clavate.
Basidium production indeterminate, acropetalous.	Basidium production determinate.
Epibasidia often produced.	No epibasidia produced.
First division of fusion nucleus horizontal, second oblique, nearly vertical.	First and second divisions horizontal.

If weight is placed on the indeterminate acropetalous production of basidia, on nuclear behavior, and on the frequent production of epibasidia, then it becomes impossible to place *Myxomycidium* in the Clavariaceae for there is little agreement between the two. Most of the characters of the genus are more primitive than would be expected in the Clavariaceae.

The Vuilleminaceae, with *Vuilleminia comedans* (Nees) Maire (3) as the type, offers a possible solution. Although the fructifications of *Vuilleminia* are resupinate, they are also gelatinous. Furthermore, each hypobasidium produces a single clavate epibasidium in which the meiotic division takes place at right angles to the long axis of the basidium. The subhymenium of *Vuilleminia* and *Myxomycidium* agree fairly well, and since both genera are gelatinous in texture, the latter genus could be considered a stipitate form derived from a resupinate one, or possibly from an as yet undiscovered pustulate form. The basidia also are strikingly similar but they differ in certain respects. In *Vuilleminia* the fusion nucleus migrates from the hypobasidium into the epibasidium and there undergoes division, whereas in *Myxomycidium* the fusion nucleus usually divides in the hypobasidium and passes after the second division into the epibasidium. Occasionally, however, instances may be observed (PLATE 39, FIG. 23) in which the

fusion nucleus migrates into the epibasidium and there divides. Still another difference is the presence of the simple type of basidium, but this difference is more apparent than real since intergradations between the two types are readily found (PLATE 39, FIG. 22, 23, 18, 12, 19). Even though there is a degree of variation in the morphology of the basidium, the fact that the vuilleminaceous type is produced is of considerable significance and points to the relationship of *Myxomycidium* to *Vuilleminia* rather than to the Clavariaceae, in which family the basidia appear to be morphologically rather constant.

The above characters point to a relationship with the Vuilleminaceae, but against this is the evidence presented by the behavior of the basidiospores, and by the presence of the larger conidium-like spores. According to Maire (**3**), the basidiospores of *Vuilleminia* become septate at maturity as a result of nuclear division and the laying down of a cross-wall, whereas those of *Myxomycidium* apparently remain one-celled and may possibly proliferate with the production of secondary spores. Also, although conidia are reported frequently in the Tremellaceae and occasionally in the Clavariaceae as shown by Coker's figure (**1**) of *Clavaria botrytis,* none have been reported in *Vuilleminia.* Since Maire was primarily interested in the cytological study of the basidium, it is possible that he overlooked the conidial stage, but even if conidia prove to be absent in that genus, it is not a point on which too great stress should be placed since in the genera of the Tremellaceae and Clavariaceae in which conidia have been reported, species occur which lack such reproductive bodies. There remains then only basidiospore behavior as an ojection to placing *Myxomycidium* in the Vuilleminaceae, but since most of the other characters indicate such a relationship to be possible, it would seem logical to include the genus in that family.

The identity of the South American and Tasmanian specimens, because of the differences in the dimensions of the basidia and spores of the two specimens, was somewhat doubtful, and the doubt was increased by the finding in Dr. Thaxter's collection of an additional specimen from Tennessee, which differed from the South American material by the presence of clamp connections at or below the basidia. Such conspicuous differences between the

North and South American material showed the desirability of studying type material, and this, through the kindness of Mr. A. D. Cotton and Miss E. M. Wakefield of the Kew Herbarium, the writer was able to do. A comparison of the three specimens definitely proved the fact that instead of dealing with one variable species, there were three to be considered. The differences between them may be indicated briefly by the following key:

1. Basidia clavate, not conspicuously narrowed below, (13.5)–25–28 × 5–7 μ; sterigmata 2 or 4, 2.5–4 μ long; spores (5)–6–7 × 4.5–5 μ ..... *M. pendulum.*
1. Basidia conspicuously narrowed below; sterigmata 4; spores 5–6.5 × 3–3.5 μ ..... 2.
2. Clamp connections absent; hypobasidia often present; sterigmata short, 2.5–4 μ ..... *M. guianense.*
2. Clamp connection present; hypobasidia seldom present; sterigmata long, 5.5–9 μ ..... *M. nodosum.*

MYXOMYCIDIUM PENDULUM Massee, Kew Bull. Mis. Inf. **1899**: 180. 1901.

Receptacula pendula, aquoso-gelatinosa, stipitata, lanceolata, apice acuta, hyalina vel basi ochraceo tincta, 1–1.5 cm. longa. Basidia clavata, (13.5)–25–28 × 5–7 μ, leniter ad bases constricta ubi 3.5–4 μ diametro; sterigmata 2 vel 4, 2.5–4 μ longa. Sporae subsphaericae vel ovoidea, inaequilaterales, apiculatae, hyalinae, glabrae, (5)–6–7 × 4.5–5 μ.

Fruiting body pendulous, watery gelatinous, stipitate, lanceolate with an acute apex, hyaline or dilute ochraceous at the base, 1–1.5 cm. long. Basidia clavate, slightly constricted towards the base, (13.5)–25–28 × 5–7 μ, tapering basally to 3.5–4 μ in diameter; sterigmata 4, less frequently 2, stout, tapering, 2.5–4 μ long. Spores subspherical to ovoid, inequilateral and usually obliquely apiculate, hyaline, smooth, (5)–6–7 × 4.5–5 μ.

Tasmania: on rotten wood, *Rodway, 605,* TYPE.

This species differs from the two following species in the proportions and dimensions of the basidia and spores. The basidia are more nearly sessile on the subtending hyphae, and although crowded in the hymenium, they are produced indeterminately and acropetalously as in the other species. Neither clamp connections nor hypobasidia were observed.

The sizes of the basidiospores as given by Massee (8–9 × 6 μ) are somewhat larger than those obtained by the writer from meas-

urements of spores from the type material. The differences may result from the fact that Massee had fresh or nearly fresh material at his disposal, whereas the present studies were made from material that had been dried for over thirty years and then mounted in lactophenol. Should Massee's measurements prove to be correct for fresh material, then the difference between this and the two following species, preserved (after having been killed in 4 per cent formalin solution) since they were collected in alcohol and glycerine, is more pronounced than it would appear from the above description.

Myxomycidium guianense sp. nov.

Receptacula pendula, aquoso-gelatinosa, breve stipitata, lanceolata, apice acuta, primum hyalina deinde ochraceo tincta, 1–3 cm. longa. Basidia 15–23 × 4.5–5.5–(7) μ, clavata, manifesto ad bases constricta ubi 1.5–2 μ diametro, saepissime ex hypobasidiis orientia; sterigmata 4 raro 3, brevia, fastigata, 2.5–4 μ longa. Sporae ovoideae vel ellipsoideae, subinaequilaterales obliquiterque apiculatae, hyalinae, glabae, 5.5–6.5 × 2.5–3.5 μ.

Fruiting bodies pendulous, watery-gelatinous, short-stipitate, lanceolate, the apices acute, at first hyaline or milky-white becoming ochraceous tinged, 1–3 cm. long. Basidia 15–23 × 4.5–5.5–(7) μ, clavate, conspicuous, constricted towards the base where they measure 1.5–2 μ in diameter, frequently arising from hypobasidia; the sterigmata 4, short and tapering, 2.5–4 μ long. The basidiospores ovoid or ellipsoid, subinequilateral and obliquely apiculate, hyaline, smooth, 5.5–6.5 × 2.5–3.5 μ.

British Guiana; Bartica, on decaying fallen tree trunk, December, 1923, *Linder, 456* and *624*, TYPE.

Myxomycidium nodosum sp. nov.

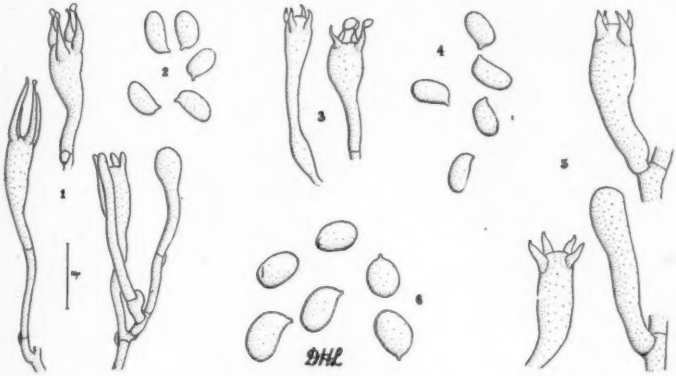
Receptacula pendula, aquoso-gelatinosa, breve stipitata, lanceolata, apice acuta, primum hyaline (?) deinde viridi-ochraceo tincta, 1–3 cm. longa. Basidia 16.5–25.5 × 4–5 μ, clavata, manifesto ad bases constricta ubi 1.5–2 μ diametro, raro ex hypobasidiis orientia; sterigmata 4, elongata fastigataque, 5.5–9 μ longa. Sporae ovoideae vel ellipsoideae, subinaequilaterales obliquiterque apiculatae, hyalinae, glabrae, 5–6 × 3–3.5 μ.

Fruiting bodies pendulous, watery gelatinous, short-stipitate, lanceolate, the apices acute, at first hyaline or milky white (?) becoming tinged greenish-ochraceous, 1–3 cm. long. Basidia 16.5–25.5 × 4–5 μ, clavate, conspicuously tapering towards the base

where they measure 1.5–2 μ in diameter, rarely arising from hypobasidia; the sterigmata 4, 5.5–9 μ long and tapering towards the apex. The basidiospores ovoid or ellipsoid, subinequilateral and obliquely apiculate, hyaline, smooth, 5–6 $\times$ 3–3.5 μ.

Tennessee: Burbank, on decaying wood, August 1896, *R. Thaxter*, TYPE.

M. nodosum, in gross appearance, very closely resembles *M. guianense* although because of the greenish color, as shown by Dr. Thaxter's water color drawings, the two species might possibly



FIGS. 1–2. *Myxomycidium nodosum* to show characteristic basidia with elongate sterigmata, the nodose-septate hyphae, and basidiospores; 3–4, *M. guianense*. Basidia and basidiospores. In figure 3, the left hand basidium is shown arising from a hypobasidium; 4–5, *M. pendulum* to show the clavate and but slightly narrowed, almost sessile basidia and the larger ovoid or subspherical basidiospores. The drawings were made from material mounted in lactophenol and are reproduced at a magnification of approximately $\times$ 1100.

be distinguished without resort to the microscope. Both of these species are alike in the structure of the context: the hyphae are rather slender and the context is differentiated into the three zones that are mentioned in an earlier paragraph. The constricted basidia and the shape of the spores would indicate that these two species are more closely related to each other than to *M. pendulum*, which produces slightly constricted basidia, and coarser and more densely arranged hyphae in the context. The presence of hypo-

basidia and the lack of clamp connections clearly differentiate *M. guianense* and *M. nodosum*, but whether the comparative lengths of the sterigmata may be relied on as of taxonomic value may be open to discussion. Certainly in the material examined, the sterigmata of *M. nodosum* were predominantly long, while those of *M. guianense* were predominantly short, but in a few cases the sterigmata of apparently abnormal basidia of *M. guianense* were as long as those of *M. nodosum*, although bluntly rounded at the tips.

The types of the two new species are deposited in the Farlow Herbarium of Harvard University, as is a microscopical preparation from the type of *M. pendulum* which is at Kew. Cotype specimens are also at The New York Botanical Garden.

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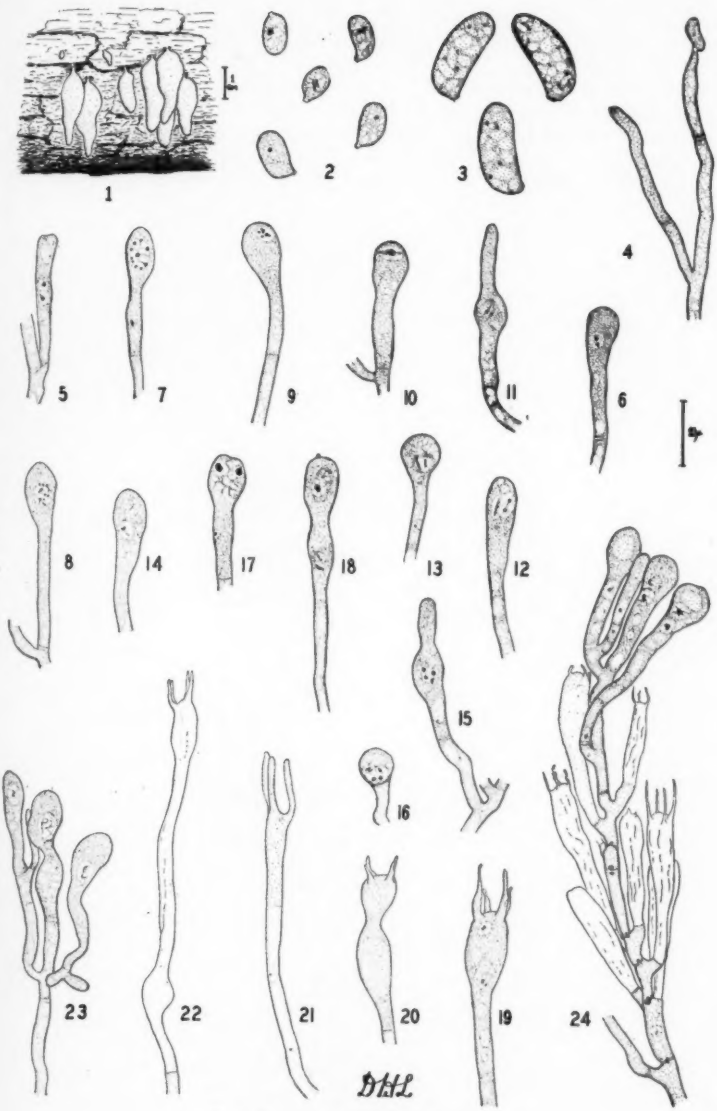
EXPLANATION OF PLATE 39

All drawings are of *Myxomycidium guianense* and with the exception of figure 1, were made with the aid of a camera lucida from material mounted in lactophenol, and as reproduced are shown at a magnification of approximately × 1125.

Fig. 1, Fruiting bodies at various stages of development to show the gregarious manner of growth. Drawing made in the field from living material. × ½; 2, Basidiospores showing the single nucleus and the rather prominent apiculus. The nucleus of the spore in the center of the group appears to be in the process of division; 3, Large multinucleate conidia that apparently belong in the life cycle of *M. guianense*. The upper right hand conidium shows a slight scar behind the apiculus,—the point of attachment of the conidium; 4, A branch from a basidium-bearing hypha on which is formed a structure that appears to be an immature conidium; 5, A young basidium showing the paired nuclei in contact, and the nucleoli with their comma-like tails directed obliquely towards the wall of the basidium; 6, A basidium in which the nuclei, but not the nucleoli, have fused. The apical portion of the basidium has already begun to enlarge; 7–8, Basidia showing the nuclei in the prophase condition. Note the peripheral arrangement of the chromatin bodies; 9, Basidium showing the fusion nucleus in the late prophase condition, at which stage eight chromosomes are evident; 10, Showing the transversely arranged spindle of the meiotic division; 11, Hypobasidium



THE GENUS MYXOMYCIDIUM

showing the obliquely dividing daughter nuclei and the formation of the elongate process that is to become the epibasidium; 12–14, The division of the daughter nuclei in the simple type of basidium. In figure 14 the nuclei are dividing at right angles to each other; 15, Four daughter nuclei in the hypobasidium which has not yet completed the formation of the epibasidium; 16–18, The simple type of basidium with four nuclei. In figure 16 the basidium is curved upwards and shows the arrangement of the nuclei as seen from above. In figures 17 and 18 the sterigmata are just beginning to form; 19, A simple basidium with four sterigmata. One nucleus can be seen as it is about to enter the sterigma above it; 20, A basidium which is only slightly constricted into an epi- and hypobasidium; 21, An apparently abortive basidium with only three stout sterigmata borne on the but slightly inflated apical region; 22, A discharged epibasidium borne on an elongate projection from the hypobasidium; 23–24, To show the characteristic method of branching and the indeterminate production of basidia by a single branch of the subhymenial hypha.

PHOTOGRAPHS AND DESCRIPTIONS OF CUP-FUNGI—XXI. THE GENUS CALYCINA [1]

FRED J. SEAVER

(WITH PLATE 40)

The above named genus was established by S. F. Gray with *Peziza firma* of Persoon as the first named species and, therefore, regarded as the type, although the genus included a number of other species not now regarded as congeneric. The genus was pre-Friesian and has apparently never been used as a valid genus since. The writer, therefore, proposes to make this genus, as typified by *Peziza firma*, post-Friesian and to include in it certain other species which in his opinion are congeneric with the proposed type.

Specimens which seem referable to *Peziza firma* Pers. have been frequently collected in North America. Probably the most commonly collected species here regarded as congeneric with the type is the so-called *Geopyxis nebulosa*. Although very often sent in for determination it is difficult to designate since it is not a *Geopyxis*, neither is *nebulosa* the correct specific name, the species having been previously described by Peck under the name *Helotium macrosporum*, a very fitting name since the large size of the spores is one of the most striking characteristics of the species.

The proposed genus is most closely related to *Ciboria* of Fuckel which again contains species which are not now regarded as congeneric. One of the characteristics of the species of the genus *Calycina* is the possession of spores which become tardily septate, the number of septa varying. Also the spores often produce small knobs or buds at one or both ends although these are not always present. Below is presented the writer's conception of the genus and the included species.

[1] This paper is preliminary to a monograph of North American Cup-fungi (inoperculates), a companion volume to North American Cup-fungi (operculates), which was published by the author and issued in December, 1928.

CALYCINA S. F. Gray, Nat. Arrang. Brit. Pl. **1**: 669. 1821.

Ciboria, Fuckel Symb. Myc. 311. 1869. (in part only).

Apothecia medium large, up to 1 cm. in diameter stipitate, or subsessile, the length of the stem varying with the conditions, light-colored or dull, externally smooth or with very poorly developed hair-like structures; asci cylindric or clavate, usually 8-spored; spores ellipsoid to fusoid, hyaline, for a long time simple later often becoming septate with one to several septa.

Spores comparatively small, not exceeding 20 μ long.
Substance of apothecia not golden-yellow. .....1. *C. firma.*
Substance of apothecia when crushed golden-yellow. .....2. *C. bolaris.*
Spores comparatively large, 30–35 μ long. .....3. *C. macrospora.*

1. CALYCINA FIRMA (Pers.) S. F. Gray, Nat. Arrang. Brit. Pl. **1**: 669. 1821.

? Peziza ochroleuca Bolton, Fungi Halifax **3**: 105. 1789.
Peziza firma Pers. Syn. Fung. 658. 1801.
Ciboria firma Fuckel, Symb. Myc. 312. 1869.
Helotium firmum Karst. Not. Soc. Fauna Fl. Fenn. **11**: 233. 1871.
Rutstroemia firma Karst. Not. Soc. Fauna Fl. Fenn. **13**: 233. 1873.
Phialea firma Gill. Champ. Fr. Discom. 101. 1882.
Hymenoscypha firma Phill. Brit. Discom. 123. 1893.
Ciboria ochroleuca Massee, Brit. Fungus Fl. **4**: 274. 1895.

Apothecia gregarious, infundibuliform, becoming expanded and often nearly discoid, stipitate, brownish reaching a diameter of 1 cm. though often smaller; hymenium brown, darker than the outside of the apothecium; stem variable in length but up to 12 mm. and .5 mm. in diameter but gradually expanding above; asci cylindric or subcylindric reaching a length of 130 μ and a diameter of 9–12 μ, 8-spored; spores ellipsoid or fusoid obliquely 1-seriate with the ends overlapping, 4–6 × 15–20 μ, at first simple, occasionally becoming 1–3-septate; paraphyses filiform, enlarged, above, reaching a diameter of 2 μ.

On woods of various kinds.

TYPE LOCALITY: Europe.

DISTRIBUTION: New York and New Hampshire to Colorado; also in Europe.

ILLUSTRATIONS: ? Bolton Hist. Fung. **3**: *pl. 105;* Boud. Ic. Myc. *pl. 483;* Gill. Champ. Fr. Discom. *pl. 74, f. 2;* E. & P. Nat. Pfl. 195, *f. 155. O, P;* Sow. Engl. Fungi *pl. 115.*

2. **Calycina bolaris** (Batsch) Seaver, comb. nov.

Peziza bolaris Batsch, Elench Fung. Cont. **1**: 221. 1786?
Ciboria bolaris Fuckel, Symb. Myc. 311. 1869.
Phialea bolaris Boud. Bull. Soc. Myc. Fr. **1**: 116. 1885.
Hymenoscypha bolaris Phill. Brit. Discom. 124. 1893.

Apothecia gregarious, stipitate or subsessile, expanding and becoming discoid or slightly convex, externally yellowish, reaching a diameter of 5–6 mm. with a few club-shaped hair-like structures about the margin; hymenium slightly concave, plane or a little convex, yellowish brown, a little darker than the outside of the apothecium; (substance of the apothecia when crushed, golden yellow); stem short, usually a little less than the diameter of the apothecium, about .5 mm. in diameter, expanding rather abruptly into the apothecium; asci cylindric or clavate, 8-spored reaching a length of 200 μ and a diameter of 12–14 μ; spores ellipsoid, usually slightly curved, 7–9 $\times$ 18–20 μ, for some time simple, finally 1-septate and often with apiculi at one or both ends, later 3-septate; paraphyses filiform, enlarged above, the contents yellow.

On twigs of various kinds.

TYPE LOCALITY: Europe.

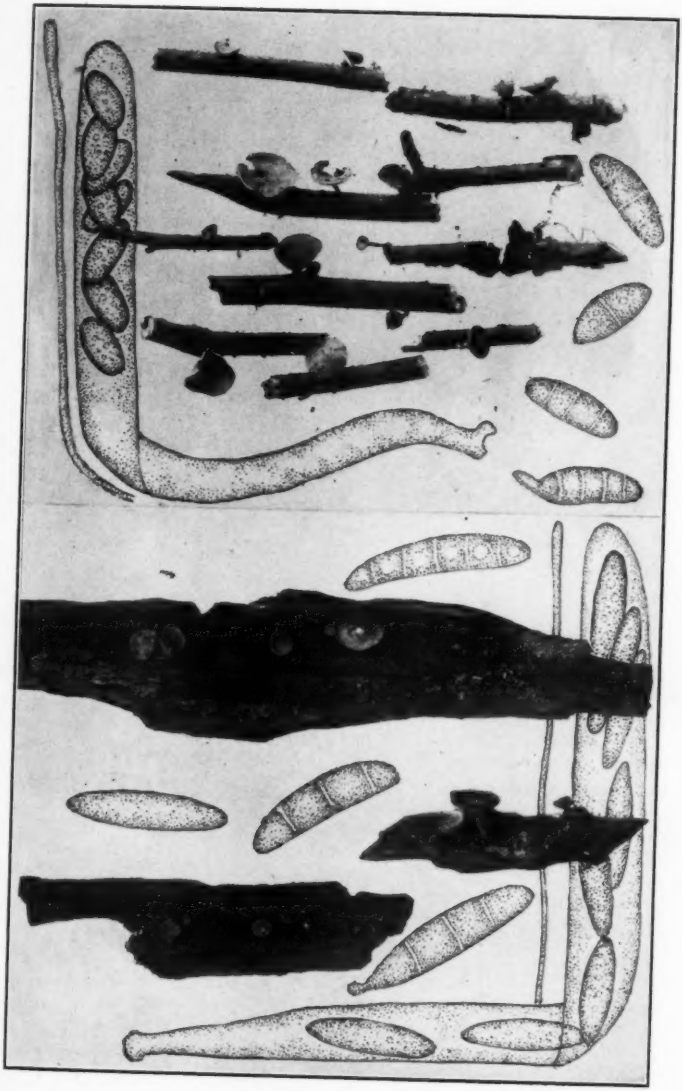
DISTRIBUTION: New York; also in Europe.

ILLUSTRATIONS: Ic. Myc. *pl. 482.*

This species is close to *Calycina firma* but seems to differ in that it is less robust and lighter colored, yellowish instead of brownish. The only American specimen seen is one collected by H. H. Whetzel, No. *10784.*

3. **Calycina macrospora** (Peck) Seaver, comb. nov.

Helotium macrosporum Peck, Ann. Rep. N. Y. State Mus. **26**: 82. 1874.
Peziza nebulosa Cooke, Mycographia 163. 1877.
Geopyxis nebulosa Sacc. Syll. Fung. **8**: 70. 1889.
Ciboria Dallasiana Ellis & Ev. Jour. Myc. **9**: 165. 1903.
Tarzetta cinerascens Rehm, Ascom. *1853;* Ann. Myc. **2**: 352. 1904.
Ciboria fuscocinerea Rehm, Ann. Myc. **7**: 525. 1909.



CALYCINA BOLARIS
CALYCINA MACROSPORA

Apothecia gregarious, stipitate or occasionally subsessile, at first closed and subglobose, gradually expanding and becoming nearly discoid, attenuated at the base, reaching a diameter of 1 cm., cinereous to yellowish-brown; hymenium concave or nearly plane, similar in color to the outside of the apothecium; stem reaching a length of 1 cm. and a diameter of about 1 mm.; asci cylindric or clavate, 8-spored, reaching a length of 150 μ and a diameter of 10–12 μ; spores narrow ellipsoid or fusoid, straight or slightly curved, hyaline granular, for a long time simple, finally becoming 1- to 5-septate and often with an apiculus at one or both ends and an oil-drop between each two septa, reaching a length of 30–35 μ and a diameter of 6–7 μ; paraphyses filiform, slightly enlarged above.

On rotten wood.

TYPE LOCALITY: South Carolina.

DISTRIBUTION: New York to Virginia, North Dakota and Colorado.

ILLUSTRATIONS: Cooke Mycographia *pl. 73, f. 281;* Seaver, Iowa Discom. *pl. 20, f. 2.*

EXSICCATI: N. Am. Fungi *477;* Rehm, Ascom. *1853;* Seaver, North Dakota Fungi *6.*

THE NEW YORK BOTANICAL GARDEN.

EXPLANATION OF PLATE 40

Upper figure. *Calycina bolaris.* Photographs of several apothecia about natural size. At the left, drawing of ascus with spores and paraphysis. At the right, several spores. Photograph furnished by H. H. Whetzel.

Lower figure. *Calycina macrospora.* Photograph of several apothecia about natural size, with drawings of ascus with spores and paraphysis. Photograph furnished by the Dominion National Museum, Canada.

NOTES ON BOLETES. III.

WALTER H. SNELL

(WITH PLATE 41)

Boletus mutabilis = *Boletus pulverulentus*

Boletus mutabilis was described by Morgan from Ohio in 1884. So far as I know, it has not been found by anyone since, but there is no question at all but that there are many species of boletes in other parts of this country than Peck's New York and Frost's New England that have never been reported, because of lack of any wide interest in these plants.

Murrill in listing this as a doubtful species,[1] said that he had not seen the types, but that Peck's New York plants are either *B. sordidus* or *B. felleus*. I do not remember whether Peck's plants were collected by him or were sent by Morgan, but in either case it seems strange that either of them would identify a true *B. sordidus* or *B. felleus* as *B. mutabilis*. Any bolete sporophore that could be called *B. mutabilis* is far from either *B. sordidus* (which I have said previously[2] may be *B. porphyrosporus,* but which perhaps is not) or *B. felleus*. Morgan's plant is characterized especially by the bright yellow stipe, tubes and flesh, with the tubes and flesh *promptly changing to deep blue*. The dark brown *B. sordidus* with light colored flesh apparently not changing to blue and the distinctive *B. felleus* with white, unchanging flesh, reticulate stipe and flesh-colored tubes are about as far removed from the plant described by Morgan as could possibly be imagined.

Inasmuch as the really distinctive feature of *B. mutabilis* as described by Morgan is the sudden changing of the flesh and tubes to blue when cut or bruised, it was most natural for one to be reminded of the extremely sensitive European *B. pulverulentus*. When descriptions of these two plants are compared, it is found that they read almost word for word, one for the other. As far

[1] Boletaceae of North America. Mycologia **1**: 16. 1909.
[2] Notes on Boletes. I. Mycologia **24**: 336. 1932.

as one can rely upon descriptions alone, it, therefore, appears that *B. mutabilis* Morgan is nothing else than *B. pulverulentus* Opat., a plant never reported as occurring in this country.

BOLETUS ROSEOTINCTUS

This species was considered by Murrill [3] to be the same as *B. Peckii* Frost, perhaps because both have a rosy-tinted pileus. I have collected what I believe to be *B. roseotinctus,* which agrees with Peck's description except for size and the stratifications of the flesh of the pileus. Examination of the specimens at Albany showed that there were specimens there larger than the dimensions given by Peck and that while some of the sporophores showed a stratification of the flesh, others did not (in the dried condition, of course).

B. roseotinctus could hardly be the same as *B. Peckii.* This latter species has a sporophore characterized by a reticulate stipe and whitish flesh changing to blue, while *B. roseotinctus* has an even, furfuraceous stipe and unchanging yellow flesh. This latter species resembles *B. subglabripes* Peck more than it does anything else (except for the pinkish color), but the spores of *B. roseotinctus* are more elliptical than subfusiform and those of *B. subglabripes* are subfusiform and not at all elliptical.

I consider *B. roseotinctus* a valid species.

THE VERSIPELLIS-SCABER COMPLEX

The tribe Versipelles of Fries contains the species with tubes white or whitish and minute, and the tube layer becoming nearly free. The American species which have been placed in this tribe are the following: *chromapes* Frost, *versipellis* Fries, *scaber* Fries, *niveus* Fries, *albellus* Peck, and *subpunctipes* Peck.

The striking and beautiful *B. chromapes* with pinkish pileus and yellow-footed stipe is readily identified. On the other hand, the remaining species of the tribe have offered considerable difficulty.

Boletus subpunctipes was described by Peck as differing from *B. versipellis* and *B. scaber* by:—the uneven, dry surface; tubes *adnate* and changing to reddish-brown where wounded; the stipe

[3] Loc. cit., p. 151.

slightly reticulate at the apex and *very minutely dotted;* spores rusty-brown or cinnamon-brown in mass instead of snuff-brown, and smaller than those of the two species last named. These differences seem to be of a minor nature, and one wonders if perhaps Peck did not have an aberrant or a faded form of *B. chromapes,* but nothing definite can be said until further studies can be made.

Boletus albellus is distinguished from *B. niveus,* the other white species, and from all the other species of this tribe, by the glabrous or nearly glabrous stipe.

The remaining species have been the subject of much controversy among mycologists. One extreme of the solutions offered is that of Murrill's, who considered *B. scaber* and *B. versipellis* the same as *B. viscidus* of Fries. It seems certain that *B. versipellis* and *B. scaber* are not the same, and they are nowhere near *B. viscidus,* which includes the *B. elbensis-B. laricinus* complex (tribe Viscipelles). As the other extreme, Fries distinguished, along with some other European forms, *B. versipellis, B. scaber, B. niveus* and *B. rugosus* (*B. leucophaeus* Pers.) and made *B. aurantiacus* (*B. rufus* of many workers) a variety of *B. scaber.* Gilbert and other French workers, including Peltereau, are very insistent that these latter species are different, but they cannot, however, follow Fries entirely. They believe that *B. aurantiacus* is not a variety of *B. scaber,* but a distinct species and they cannot be sure about *B. versipellis.* Gilbert [4] says that apparently Fries himself had no precise idea what *B. versipellis* was and that he changed his concepts of it in successive treatises. Therefore, because of this uncertainty and confusion, he would call it *B. floccopodus* (in his arrangement, *Krombholzia floccopoda*). He chose this specific name because it is something like *floccopus* under which name Rostkovius described the species, but which will not hold for *B. versipellis,* because *B. floccopus* is *Strobilomyces strobilaceus.*

In the light of the foregoing confusion, I have made some study of these forms macroscopically and microscopically and I am inclined pretty much to agree with Gilbert. I believe that the following species can readily be distinguished in the northeastern

[4] Personal correspondence and "Les Bolets," p. 183. Paris. 1931.

states:—*aurantiacus, versipellis* (or if one prefers, *floccopodus*), *scaber, leucophaeus* and *niveus*. I believe they can be distinguished as follows:—

Boletus aurantiacus—pileus usually more orange than *B. versipellis*, although often not, and not so reddish as described and portrayed by Europeans; surface dry, *tomentose;* margin always appendiculate with the projecting pellicle (not a veil); flesh white, changing to roseate and then to violaceous-rosy; stipe with asperities at first white, *then reddish, finally brownish;* spores *elongate-elliptical* or *narrowly subfusiform*, pale greenish under the microscope, and 13–15 × 3–3.5 μ; cystidia common, ventricose, globose-papillate or fusiform; probably the only one occurring under conifers as well as under poplars and birches; rare.

Boletus versipellis (or *floccopodus*)—pileus usually more orange-*yellow;* surface dull, unpolished, *glabrous* to more or less fibrillose-granulose under a lens; margin, color-changes of flesh, and cystidia as in *B. aurantiacus;* spores *elliptic*-fusiform, pale greenish under the microscope, 11–16 × 3.5–4 μ; occasional under birches.

Boletus scaber—pileus grayish or isabelline to brownish; surface glabrous, usually viscid; margin *usually not appendiculate*, but occasionally so; flesh white becoming more or less grayish or dingy violaceous; stipe with asperities at first white, then grayish and finally blackish; spores mostly *broadly elliptical* to *fusiform-elliptical* (not so fusiform as those of *B. versipellis*), *olivaceous-brown under the microscope*, 13–21 × 4–7 μ, mostly 16–18 × 4–6 μ, but larger or smaller, varying with the specimen, some as long and some as broad as those of *B. leucophaeus*, but none both as long and as broad; cystidia rare or lacking, ventricose-rostrate to clavate; very common under birches.

Boletus leucophaeus—pileus *dark-brown* to *blackish*, disc usually black; surface dry, strongly *tomentose;* white flesh becoming grayish or blackish; margin not appendiculate as far as observed; stipe somewhat darker than that of *B. scaber*, more rugose, with asperities nearly black; spores olivaceous brown under microscope, elliptical or subfusiform, *large*, 17–21 × 6–7 μ; cystidia not found; rare, under birches in mixed hardwoods and conifers (as far as observed).

Boletus niveus—pileus white or whitish; flesh *very firm* becoming more or less blackish; stipe scurfy or appressed scaly, but not so pronouncedly as the stipes of other species; spores olivaceous brown under the microscope, fusiform-elliptical, 13–20 × 5–6 μ.

Briefly, there are five distinct species in the *versipellis-scaber* complex—on the one hand, the orange-capped, cystidiate *aurantiacus* and *versipellis* (or *floccopodus*) with flesh becoming more or less roseate or violaceous, and on the other hand, the dull-colored or whitish, rarely cystidiate *scaber, leucophaeus* and *niveus* with flesh not becoming roseate or violaceous. *B. aurantiacus* has the pileus distinctly tomentose at least in part, usually entirely so, and the asperities of the stipe become reddish and finally dark brown. *B. versipellis* has a pileus glabrous or at best fibrillose-granulose under a lens, with the roughenings of the stipe becoming more blackish. *B. scaber* is glabrous, viscid, grayish, isabelline to brownish. *B. leucophaecus* is distinctly and roughly tomentose, dark brown to black. *B. niveus* is whitish with a smoother stipe than any of the other species. These species can readily be distinguished by the spore characters alone. Examination of the spores is in fact the only certain way to distinguish them (see PLATE 41), as for example, when one finds a sporophore which is quite isabelline or brownish (as of *B. scaber*) but which has a distinct orange tinge (as of *B. aurantiacus* or *B. versipellis*). These two latter species are nearly alike as to color and not easily distinguishable in this country, as they are in Europe, where the former is said to be more reddish-orange and the latter more yellow.

CERTAIN SPECIES OF THE GRANULATUS GROUP

What may be called the *granulatus* group of the Viscipelles consists of those species with exannulate, glandular-dotted stipe, even if the glandular dots are apparent only on occasional specimens. There has been a great deal of misunderstanding with regard to some of these species and difficulty has been experienced in identifying with certainty some of the others of the group.

I can offer no assistance with regard to certain of the species. I am not familiar with the western *B. flaviporus* Earle. I have not collected *B. albidipes* named by Peck, who says it is distinguished by pileus paler than that of *B. granulatus*, especially when

young, by the usual lack of dots at the top of the stipe and on the edges of the tubes (although there are occasionally a few), and by white stipe without any yellow.

Murrill made out *B. rubropunctus* Peck to be the same as *B. inflexus* Peck. I have never collected *B. inflexus,* but I have seen *B. rubropunctus* and, finding this species to be exactly as Peck described it, I am inclined to think that *B. inflexus* will be found to be distinct.

I have already pointed out that *B. placidus* and *B. brevipes* are readily distinguishable from *B. granulatus.*[5]

The other species of this group are the following: *punctipes, americanus, hirtellus* and *subaureus*—all named by Peck.

Boletus hirtellus is closely related to *B. subaureus* and I have found forms which have some of the characteristics of *B. americanus,* notably the vermilion streaks occasionally found in that species. I have also found some forms late in the fall after cold weather that had definitely boletinoid tube layers. I am reserving judgment regarding these latter forms, but in any case, the species is readily recognized by the hirtose pileus and dark color of the spore mass.

Murrill placed *B. americanus* in *B. subaureus* and *B. punctipes* in *B. granulatus.*[6] Not only is this arrangement wrong, but furthermore, the two most similar species of these forms are the middle pair—*B. subaureus* and *B. punctipes.* I have never had any trouble recognizing *B. americanus,* but I have had to learn to distinguish *B. punctipes* under certain conditions, especially before the glandular fluid of the latter becomes darkened.

Boletus americanus differs from *B. subaureus* in the following respects:—pileus more yellow (not so pale), not marked with brown by the drying gluten but with reddish streaks; pores larger and of a duller yellow color; stipe more slender, with the exuding drops whitish instead of yellow, and the flesh not reddish within at the base; the spores slightly larger; and the odor and taste usually farinaceous instead of mild and unnoticeable. *B. americanus* cannot be confused with any other species.

Boletus punctipes is nothing like *B. granulatus.* It differs in

[5] Notes on Boletes. II. Mycologia **25**: 231. 1933.
[6] Loc. cit., p. 13.

every one of the characters which are used to describe these forms —stature, color of pileus, margin, color of flesh, color of tubes, color of stipe within and without, type of glandular dots, size of spores, and cystidia. Everyone knows *B. granulatus* with pileus at first dark then pale, with flesh mostly white, with ochraceous glandular-dotted tubes and with white stipe finely dotted and yellowish above. *B. punctipes* is yellowish to cinnamon-buff on the pileus, with flesh yellowish, tubes brownish to brown, stipe *rhubarb-yellow* and thickly covered with large masses of glandular secretion that are soon brown and have a peculiar *sticky-waxy* feeling. The spores of *B. punctipes* are 9–11 × 3–4 μ, those of *B. granulatus* are mostly 6–7 × 2.5–3 μ.

Boletus subaureus and *B. punctipes* are usually readily distinguishable when mature. *B. subaureus* is always pale yellow on the pileus, the tubes are medium-sized and yellow to ochraceous, the stipe is yellow and has a more or less patchy, reddish-brown to brown glandular secretion. *B. punctipes* is yellow, but becomes cinnamon brown on the pileus, the tubes are always brownish to brown and small, the stipe is that peculiar rhubarb yellow with the closely-packed, brown, sticky-waxy-feeling glandular masses of dried secretion. No one can fail to recognize *B. punctipes* when mature.

When, however, as mentioned above, *B. punctipes* is young, with the pale-colored pileus and the pale-colored glandular dots, it is likely to be confused with *B. subaureus* in the field. When the young specimens are brought in and dried, usually the characteristic features of *B. punctipes* appear sufficiently distinctly for a diagnosis. If they do not, an examination of the spores will not fail to separate them. If all but the immature ones are over 9 μ long, it is *B. punctipes;* if all but a very few are under 9 μ long, with those few up to 10 μ long, it is *B. subaureus.* I have found this criterion infallible. *B. punctipes* also has the cystidia cylindrical to clavate. *B. subaureus* has them irregular to more or less fusiform.

THE EDULIS GROUP

Murrill included in *B. edulis*[7] (his *Ceriomyces crassus*) a number of species considered distinct by Frost and Peck. It seems to

[7] Loc. cit., p. 149.

me that most of these are good species, readily distinguished and easily recognizable.

Frost briefly described *B. limatulus* as differing from *B. edulis* only in the viscid pileus and the tube mouths yellowish-brown. *B. edulis* is often viscid or even viscose, and the tube mouths are often brownish. This is one case, therefore, in which Murrill was probably correct and this name is to be reduced to synonymy.

Frost also inadequately described another plant as *B. decorus,* differing from *B. edulis* in its tomentose to squamulose pileus, brownish-red, furfuraceous, non-reticulate stipe and tubes becoming greenish when wounded. As far as is known, no one since Frost has found this plant. This past summer, however, I found some sporophores which fit Frost's meager description in all but a few particulars. My specimens, not quite mature, were hardly tomentose on the surface, had tubes at first white and later yellow, turning rusty brown, particularly when young and white and more or less dry, and had spores a little longer than Frost's single figure. It is nothing strange to find such minor differences where the early descriptions were habitually incomplete. Frost emphasized the turning green of the tubes when wounded, but there is no way of telling whether he meant a real blue-green or a mere watery-greenish which is often assumed by crushed tubes of many species.

It appears possible that I have collected something very close to *B. decorus* and perhaps actually what Frost had, and that possibly it is a good species. I am awaiting further collections and holding the matter open. It may be added that the plants I have appear to be related to *B. eximius* and are nothing like *B. edulis.*

Murrill states that most of the other American forms [8] can be placed in Peck's varieties *clavipes,* with stipe reticulate to the base, or *separans,* with brownish-lilac cap and stipe. It appears to me that such a disposition of these forms would necessitate stretching a species concept too far. I have collected the other forms named by Peck and find them to be easily identified according to Peck's descriptions and sufficiently unlike *B. edulis* to retain their autonomy.

Boletus separans was distinguished by Peck on the basis of its adnate tubes which often separate from the stipe, its brownish-red

[8] Loc. cit., p. 149.

or brownish-lilac pileus and stipe, and strongly subacid odor while drying. The separating tubes are often noticed, but are not distinctive. The spores are very similar to those of *B. edulis,* but the stature, colors and general appearance of *B. separans* readily distinguish it.

Murrill was uncertain about including *B. auripes* in *B. edulis* and rightly so. The pileus is yellowish brown, the tubes and stipe are yellow and the flesh is yellow fading to white. These are distinctive characters.

Boletus nobilis differs from *B. edulis* in the following characters:—tubes not depressed around the stipe and without greenish tint; the flesh thin even in every large specimens, pure white except where it is yellow next to the tubes instead of more or less reddish brown; stipe white or pallid, often with a lilaceous tinge in places; and spores not so ventricose or pointed. In large troops of this species, I have occasionally found specimens with pileus more or less bleached to pure white.

Boletus Atkinsoni is distinguished by: pileus more grayish to grayish-brown than yellowish-brown or reddish-brown, with fibrillose-squamulose to rimose-squamulose surface; tube layer not much, if at all, depressed around the stipe.

Boletus variipes is very similar to *B. Atkinsoni,* but with longer and more fusiform spores.

BOLETUS CURTISII

Along with some other very interesting specimens recently sent by Mr. H. C. Beardslee was a sporophore of *B. carolinensis.* This species was described by him [9] on the assurance of another mycologist that it was distinct from *B. Curtisii* Berk. in its stipe being even instead of reticulate, as is supposed to be the case with *B. Curtisii.* Study of the specimen and of Beardslee's excellent colored photographs and notes showed that his species agrees precisely in every other particular with the usual descriptions of *B. Curtisii,* especially as to the elliptical yellow spores.

Such close agreement of the two descriptions stimulated my interest, particularly because very few of the Boletaceae possess yellow spores. I began to wonder if perhaps there had been a

[9] Jour. Elisha Mitchell Soc. **31**: 147. 1915.

mistranscription of the original description or if Berkeley had possibly made an error in his accounts of the species. Further, I remembered Peck's statement regarding *B. Curtisii* [10]—" . . . The viscose pellicle indicates a relationship to the Viscipelles, with which the reticulated stem does not harmonize. The nearly free tubes point toward the Edules against which the slender stem and unstuffed tubes militate. It is also incongruous among the Calopodes but as there seems to be no better place for it, we place it here for the present."

Returning to the original description,[11] I found that Berkeley made no mention in either the Latin or the English texts, of the stipe being reticulate. His words follow: " . . . *stipite inaequali, exannulato, cavo, stramineo;* . . . stem irregular, unequal, hollow, ringless, 2–3 inches high, ¼ of an inch thick, pale or straw-colored." On the other hand, in the later description [12] he gives the stipe as "*reticulato.*" It is this later description which has been reproduced by other mycologists.

Examination of specimens of *B. Curtisii* in the New York Botanical Garden showed that the stipes are not reticulate, except possibly in places from the slightly decurrent walls of the tubes. Likewise, no sign of reticulation could be found on the stipe of the plants in the Curtis Herbarium at the Farlow Herbarium at Harvard. It is quite likely, but not certain, that these plants are cotypes.

It is clear, therefore, that *B. Curtisii* does not have a reticulate stipe and that *B. carolinensis* is the same species.

Since *B. Curtisii* does not have a reticulate stipe, it does not belong in the tribe Calopodes, where it is out of place because of its very viscose pileus, its hollow stipe and elliptical yellow spores. In which tribe to place it is somewhat of a problem.

There are three possibilities. Peck suggested the Edules because of the nearly free tubes. The tubes appear to be fundamentally adnate, but on the other hand Beardslee writes that the pores seem to be stuffed at first. Until this matter is settled, this plant cannot be put in the Edules.

[10] Boleti of the United States. Bull. N. Y. State Mus. **8**: 128. 1889.
[11] Ann. Mag. Nat. Hist. II. **12**: 429. 1853.
[12] Grevillea **1**: 35. 1872.

The second possibility is the tribe Cariosi, along with *B. castaneus, B. subalbellus,* and *B. cyanescens,* because of the hollow stipe, yellow, elliptical spores and tendency towards freedom of the tubes. The adverse considerations are the fundamentally adnate tubes, the lack of a truly oblong-elliptical shape of the spores, and the very viscose pileus. The Cariosi are decidedly dry.

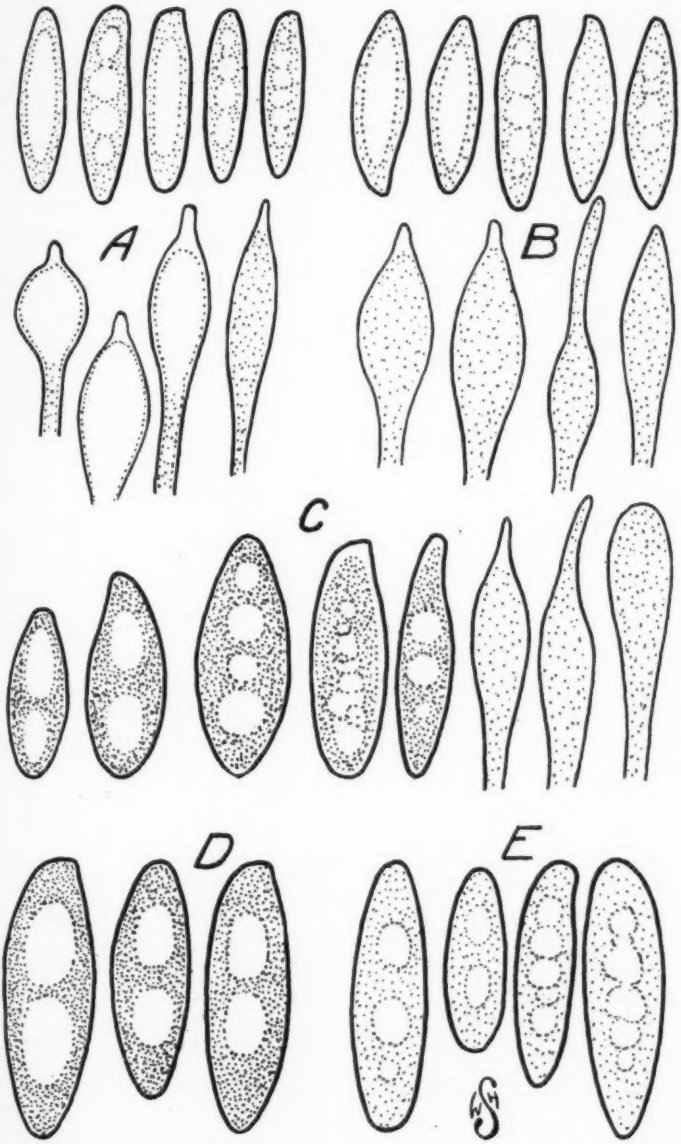
The third possibility is the Viscipelles because of the viscose pileus, adnate to decurrent tubes at least up to semi-maturity, and the elliptical spores. The characters which militate against this disposition of the species are the yellowness of the spores, and the hollow stipe. There are no species in the Viscipelles which have deep yellow spores although a few have pale yellow ones. There are no species with a truly hollow stipe. I am inclined to discount the previous reports of nearly free tubes. In Beardslee's specimens, the tubes are decidedly adnate to subdecurrent, although at the same time somewhat depressed or sinuate. The dried specimens that I have examined have the tubes much torn away for the most part, but in places still subdecurrent.

In view of these facts it seems best, on the basis of available information, to place *B. Curtisii* in the Viscipelles, while recognizing its relationship with the Cariosi.

One other point that would be of importance in settling the matter of placing *B. Curtisii* is the putrescibility or imputrescibility of the sporophore. The Cariosi are imputrescible while the Viscipelles are decidedly putrescible. Such information is at present lacking.

EELWORMS AS DESTROYERS OF FLESHY FUNGI

I suppose that it is nothing uncommon to find sporophores of the fleshy fungi in the process of rapid deterioration because of infestation by myriads of eelworms, but I am not familiar with any references to it. I first noticed that in certain localities all of the Bolete sporophores were being very rapidly reduced to a watery-slimy mess by what appeared to be a mold. The rapid deterioration of the fruit bodies was very striking. On a hand-lens examination of some specimens appearing only slightly "moldy," it was found that what appeared like hyphae slightly projecting from the surface of the entire sporophore were filamentous structures rapidly waving back and forth. These were



SPORES AND CYSTIDIA OF BOLETUS

found to be eelworms. Completely destroyed masses were a writhing mass of these minute animals.

Since that time I have examined many "moldy" fleshy forms and find that only occasionally is the "molding" of Agarics due to eelworms, but that eelworm "molding" is quite common in the Boletes. A true molding of the fleshy fungi will often result in a mummification of the fleshy sporophores, which will leave them identifiable, but it has proved very disconcerting to leave immature Boletes *in situ* for further observation, only to find that in a few hours they have collapsed to the ground in a slimy, putrid mass because of eelworm infestation.

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EXPLANATION OF PLATE 41

Spores and cystidia of the *scaber-versipellis* complex A, *B. aurantiacus;* B, *B. versipellis;* C, *B. scaber;* D, *B. leucophaeus;* E, *B. niveus.* Magnification—spores × 2000; cystidia × 1000.

A LETHAL FOR ASCUS ABORTION IN NEUROSPORA

B. O. Dodge

(WITH PLATES 42–44 AND TWO TEXT FIGURES)

Many species of fungi usually present fairly reliable diagnostic features when grown under standardized cultural conditions. Now and then, the mycelium may begin to grow out abnormally at some spot in the plate and form a sector which differs considerably from the rest of the culture in color, habit of growth, or in the amount of sporulation. An extensive literature covering the phenomenon known as "sectoring" has appeared in recent years. It is usually claimed that a mutant has been obtained because transfers from the sectored area continue to show the same abnormal type of growth, "generation after generation." In case of certain species of *Botrytis* and *Helminthosporium* where the sexual stage is unknown they were merely keeping the same individual, the same generation, alive by repeated transfers to fresh media.

Treatment of fungi with x-rays and ultraviolet light, in addition to the killing action resulting from large doses, is said to have resulted in some mutations, or in the production of ascocarps by races otherwise not ordinarily fertile. No genetic effects, however, in the cases reported, have been proved other than by vegetative propagation. *Aspergillus, Glomerella* and other forms that have been treated, can be made to produce ascocarps in culture without irradiation, but no one has adequately proved out the mutations claimed by a study of progeny obtained through sexual reproduction.

The genus *Neurospora* with its three species available for culture work affords excellent material for a study of naturally occurring mutations as well as for a study of the genetic effects obtained by treatment with x-rays or ultraviolet light. For example, when an albino non-conidial strain of *N. sitophila* appeared

during some of the writer's work, it was easy to prove that this race was in the nature of a mutant (Dodge, 1930, 1931). By mating it with a normal conidial race it was proved in every case that segregation of the factors for conidium production occurred at meiosis so that four of the ascospores in each ascus gave rise to albino non-conidial mycelia and four to mycelia which produced the orange-colored conidia normally. When two albinos were mated, all of the eight progeny ascospores in each ascus produced albino non-conidial mycelia, showing perfect Mendelian inheritance. Progeny of several generations when interbred show the same segregation, proving that the albino race arose as a mutation.

ABORTED INDURATED ASCI

Among various abnormalities that have come to the writer's notice while culturing *Neurospora* species and their hybrids, was a peculiar type of ascus abortion. Certain ascocarps produced some asci in which no spores had ever been delimited. Other asci contained normal ascospores. The aborted ascus, as it increased in size, gradually changed from a thin-walled colorless structure, to a deeply colored thick-walled body with striations resembling those normally present on the ascospores themselves (TEXT FIG. 1). These monstrosities have been found several different times; twice, in 1926 and 1929 (PLATE 42, C), in cultures of *N. tetrasperma* (strains $S_1 \times S_6$), and in 1927 in four or five cultures of F_2 hybrid origin, *N. tetrasperma* × *N. sitophila* being the original parent mating (PLATE 43, A). One such ascus was illustrated at that time (Dodge, 1928). Beyond pointing out in the legend for the plate that their nature was not understood nothing further was said. Each time they were discovered in the cultures permanent mounts were preserved, and transfers were made to fresh media to see if the abnormality carried over into the subcultures. Whether the subcultures actually developed new perithecia with aborted asci is uncertain because, in the press of other work, this important point was not followed up. It is certain that most of the subcultures failed to show ascus abortion, otherwise the cultures would have been continued. Except for four of the original cultures obtained in 1929, the cultures were finally discarded. These were preserved in their dried condition and today, now

that the subject has come up in an entirely different connection, furnish additional interesting material for genetic studies.

X-RAY TREATMENT OF ASCOSPORES AND ASCUS ABORTION

Uber and Goddard (1934), working with *Neurospora tetrasperma,* treated normal ascospores with x-rays in their studies on the killing effects of various doses. I am greatly indebted to these authors, through Dr. Goddard, for seven cultures selected at random from their series "G," cultures that had been obtained from their x-rayed ascospores. These were normally bisexual spores, but the treatment appeared to have rendered them practically, or in some cases, actually, self-sterile so far as the production of ascocarps is concerned. Testing these races for loss of sexuality by mating them against my own tester strains, S_1 and S_6, it was found that the treatment, among other effects, had largely inactivated sexually, in each case, both nuclei of the same sex originally present in the ascospore. Their strains G_4–2, G_4–4, G_5–1, and G_5–3 proved to be sex A in their reaction, while strains G_4–1, G_4–3 and G_5–1 reacted as sex B. G_4–3 and G_4–1 were thought to be actually neutral because in the first trial tests they gave no perithecia with asci when grown with either tester strain. Later tests, however, against S_6 resulted positively. They react very weakly as sex B.

One culture, G_5–3, proved most interesting. When grown alone on corn meal agar a number of large sterile perithecial bodies will develop. Occasionally one finds a few very poorly developed ascospores and one or two aborted indurated asci like those figured in plate 42. Grown against tester strain S_1, many perithecia with asci mature within ten days. In every one of the many perithecia chosen at random from seventeen different test cultures examined, there were found numbers of the aborted indurated asci mentioned above. They were mixed in with some fairly normal asci containing ascospores. Cytological studies made in 1929, to be reported later, indicated that these indurated asci were dead structures. Nevertheless, attempts to induce them to germinate were made, but without success.

Previous work on *Neurospora* had proved that in case of heterothallic races of opposite sex mated to produce perithecia, two nu-

clei, one from each of the two races, come together in each ascus and fuse. If ascus abortion here is a genetic question, that is, if the active nuclei of race G_5–3 are carrying the lethal factor responsible for ascus abortion, each ascus in every perithecium from the mating must contain such a factor, whether the ascus aborts without delimiting spores, or whether ascospores are actually matured. The mechanics by which each ascospore of *N. tetrasperma* is provided at its origin, with two nuclei of opposite sex, would provide one nucleus carrying the non-lethal element from S_1 the tester strain, and also one nucleus carrying the lethal from G_5–3. This means that every ascospore from the mating, should it germinate, would give rise to a mycelium which in turn must also produce perithecia with the usual percentage of aborted asci. Culture studies described below prove beyond a doubt that ascus abortion has a genetic basis.

Culture studies, first mating

Using race G_5–3 as one parent (sex A) and race S_1 (sex B tester) as the other parent, seventeen tube cultures on corn meal agar were started. At the end of ten days perithecia were sufficiently matured to learn that every one examined from each culture contained some aborted asci. Each perithecium always produced some mature ascospores. While normal *N. tetrasperma* does mature a few asci with other than four spores, perithecia from these (G_5–3) $\times$ S_1 cultures produced a much greater number proportionally of asci containing unisexual spores. Figure B, plate 42 shows an eight-spored ascus, four spores of which would have matured, the other four probably would have died even if they had germinated.

It should be noted here that the mycelium of the Uber and Goddard strain (G_5–3) is usually not at all normal in transfers to corn meal agar plates. Here it is often dwarfed, requiring from a week to ten days to grow over the plate. A normal mycelium would cover the plate within a day or two. Growth and branching of G_5–3 is more or less irregular and intermittent. Occasionally, however, this race tends to sector and revert to normal growth. Since the mycelium is heterokaryotic some of these irregularities may be due to the chance distribution of the four possible different

kinds of nuclei present after the x-ray treatment, a point which must be fully considered in interpreting results from irradiation. Each normal mature ascospore has four nuclei instead of two. There are two of each sex so that one nucleus of each sex could be killed outright yet if the other two nuclei in the spore had escaped injury the derived mycelium would still be bisexual and normal. Again, of the two nuclei of each sex, one in each set might be altered or killed, so that while normally there are only two kinds of nuclei, genetically, there may be four kinds after irradiation. Whether ascus abortion and dwarfing of mycelium are linked or in any way genetically connected is a question for further study. A more complete analysis of the original culture by plating out the conidia would have thrown some light on this question.

Cultures from f_1 ascospores

As noted above, the seventeen cultures from the mating $(G_5\text{–}3) \times S_1$ developed perithecia containing some aborted asci as well as some mature ascospores. Ascospores chosen at random from different cultures were given the heat treatment. In selecting the germinated spores for transfer no particular kind was had in mind. The following spores designated by numbers were proved to be bisexual since perithecia were formed on their mycelia through self-fertilization. These perithecia produced some aborted asci as well as some mature ascospores. Nos. 1, 2, 3, 4, 6, 8, 9, 10, 11, 12, 14, 16, 18, 19, 21, 22, 23, 24, 25, 27, 28, 29, 30, 31, 33, and 38, or twenty-six in all, were bisexual. Certain ones, notably nos. 19 and 25, were very weakly bisexual. Two mycelia nos. 13 and 32 were unisexual, sex A, while nos. 7, 15, 17, and 20 were unisexual, sex B. Mycelium no. 35 continues to be very much dwarfed. It did not react sexually with either of the tester strains in the first tests. In later tests, however, it did react weakly as sex A. Three other ascospores, nos. 36, 37 and 39, failed to form mycelia after having germinated.

Perithecia from the f_1 mycelia

Having found that, of the many examined, every perithecium resulting from the mating $(G_5\text{–}3) \times S_1$ contained some aborted in-

durated asci, it was now of great interest to see if the lethal had carried over to the next generation by means of the f_1 ascospores. At the end of about ten days a sampling was made of a few perithecia taken from each of the 26 fertile cultures listed above. Every perithecium crushed out showed some aborted asci. Races nos. 1, 2, 3, and 4 had also been grown in petri dish cultures where each matured many hundreds of perithecia. Small squares covering about 50 fruit bodies were marked off in each culture and every perithecium in each block was examined. In no case was there a failure to find aborted asci.

Perithecia from matings of mycelia from unisexual f_1 ascospores

The sex of the unisexual mycelia nos. 7, 13, 15, 17, 20, 32, and 35 had been determined by growing them separately with S_1 and S_6 as testers. Examination of the perithecia resulting from the matings showed not a single aborted ascus. Likewise when nos. 13 and 32 were mated with nos. 7, 15, 17 and 20 in pairs, the resulting perithecia all produced large numbers of normal asci, but no aborted indurated asci (PLATE 44, B). This is very easily explained if the lethal that often prevents delimitation of ascospores also inhibits germination or prevents the full development of mycelia by unisexual ascospores, even though they may germinate somewhat. A haplo-deficiency should have just this effect.

Mycelia from f_2 ascospores

Some of the ascospores that had been discharged on the petri dish covers in case of cultures nos. 1, 3 and 4, were given the heat treatment. After the spores had germinated selections were made rather roughly on the basis of size and type of germination. This would give us three classes. The larger spores would be bisexual, the smaller ones unisexual, and those with abnormal germ tubes would form a third class. The number of spores in each class has no particular significance in this case. Fifty-six spores transferred proved to be bisexual since their mycelia produced perithecia.

Of the small unisexual spores chosen eight were proved to be of sex A in their reaction and twelve were sex B. Fifteen small

spores died after having germinated. Some of them did make a mycelium a few millimeters long before dying, however. There appeared to be several grades between those that died immediately after germinating and those that made fairly normal mycelia. In general they could be classed either as abnormal (dwarfed) mycelia or as normal mycelia. Fourteen of the mycelia originally classed as more or less dwarfed are still living at this writing. They grow very slowly, but it has been proved that they do not carry the lethal for ascus abortion.

Perithecia from f_2 mycelia

A further and still more convincing proof that the lethal factor responsible for ascus abortion is segregated at meiosis is found on examining perithecia developed in the 56 cultures obtained from the bisexual f_2 ascospores. Several samples taken from each of the cultures showed aborted indurated asci in each case. No perithecium was found lacking these structures. A few of the cultures such as nos. 4.2, 4.8 and 4.13 showed weak sexuality. This led to confusion because they were at first classed as unisexual. Whenever perithecia matured, however, through self-fertilization, aborted asci were always present. Testing the unisexual races against the tester strains S_1 and S_6, and later against one another in various combinations, the perithecia resulting have given not a single aborted ascus. Race 3.31 was classed as a dwarf mycelium yet it continues to live, and it reacts very weakly with tester race S_1 to produce a few very abnormal perithecia. These contain some abnormal asci, but that they would have become wholly aborted and indurated is doubtful. It is clear that a small uninucleated spore may carry some factor for dwarfed mycelium and still be able to germinate and form a functional mycelium. Since race 3.31 mates with only S_1 tester it reacts as unisexual. In any case it would seem that the lethal action is not strong enough to entirely prevent growth and sexual reproduction.

Mycelia and perithecia from f_3 and f_4 ascospores

If one heats the ascospores for an hour at 60° C. they will usually germinate sufficiently within the next six or eight hours to

enable one to determine which ones will probably die after making a slight growth. If they do make further growth, only a dwarfed mycelium may be expected. The perithecial culture 4.11 (G_5–3) $\times S_1$ furnished the f_3 ascospores for further testing one's ability to quickly select from spores showing short germ tubes, unisexual spores that will die soon after germinating.

Sixty-two germinating spores were selected. Of these nine were judged by their size to be bisexual, but their germ tubes appeared to be abnormal or dwarfed. Only no. 4.11.3 gave normal mycelial growth. It was unisexual, however, in its reaction. The other eight all died without making much further growth.

Eleven of the sixty-two were thought to be "rather small" and with "rather dwarfed" germ tubes. Four of these died without producing further growth, one made a dwarfed mycelium that has lived and grown slowly. Six gave rise to normal mycelial growth; only one proved to be bisexual.

Six spores were judged to be very small and "thin," but some of them had rather good germ tubes. Two of the six died without much further growth. Two gave dwarf mycelia of very slow growth, and two produced mycelia of normal growth, one of them being bisexual.

Of the seven small spores thought to be giving normal growth, six continued to grow well and one died without further growth.

It is of interest to see, without further details, that of the 49 spores judged to be germinating as dwarfs, or at least rather abnormally, 37 died after the germ tubes had added a few short branches, seven produced dwarfed mycelia of very slow growth. Only four of the whole number, 62, gave rise to fertile mycelia. This is explained by the fact, as noted previously, that the larger spores are commonly bisexual and they were, therefore, purposely avoided in this experiment, unless they appeared to be germinating very abnormally. The four exceptions were nos. 4.11.13, 4.11.18, 4.11.25, and 4.11.45. Their perithecia produced the usual percentage of aborted asci. This proves that the lethal factor was carried through the third sexual generation.

As a further test eight f_1 ascospores from culture 4.11.25 were germinated. Perithecia from each of the cultures thus obtained contained the indurated asci.

PERITHECIA IN SUBCULTURES

The lethal for aborted asci is perpetuated through the bisexual ascospores but not necessarily through a series of subcultures derived by transfers from old cultures, such as 4.11.25, after they have discharged ascospores. Fifty per cent of the small unisexual spores would be normal, and if some of them germinate after being transferred their mycelia, mating, would develop perithecia without any indurated asci. For example, two subcultures were made from each of the old cultures 4.11.18, 4.11.25, and 4.11.45. These six subcultures all developed some perithecia that did not contain any aborted asci. Other perithecia in the same cultures contained some of these structures.

NUCLEAR BEHAVIOR DURING ASCUS ABORTION

Cytological preparations made in 1929 from material representing perithecia of *N. tetrasperma* with aborted asci, and preparations made from cultures derived from the Uber and Goddard x-rayed ascospore show the same sort of nuclear degeneration. The perithecia develop to full size and form the ostiole as usual. Young asci with fusion nuclei are rather plentiful. They contain a fine granular content and take the stain deeply. Similar preparations of normal material show many examples of clear cut division figures in all three nuclear divisions. It is a very different story here. The spindle figures in aborting asci are so abnormal, no doubt due in part to improper fixations, that one cannot make out the details. Normally after the third division the eight nuclei pair up, one of each sex, giving four pairs, and each pair cuts out an ascospore. The two nuclei in the spore round up as they move back from the end of the spore, and soon after divide for the fourth time simultaneously with the nuclei of the other three spores. Every ascus of *Neurospora* then, regardless of which species is considered, at maturity contains within the spores its complement of sixteen nuclei. If an ascus contains five spores, two of them will be small and unisexual, and each of them will contain at maturity two nuclei of the same sex reaction. It would seem to be inherent in *Neurospora* for the primary fusion nucleus to undergo four successive nuclear divisions, three before, and one after, spore delimitation.

The same inheritance operates even though the fusion nucleus contains the lethal factor or deficiency for ascus abortion. In some cases the fourth division occurs immediately following the third without waiting to delimit the ascospores. The nuclei then migrate to the wall of the ascus, the spindle of the fourth division still showing between the opposite members of each pair (PLATE 44). Further study may show, however, cases of lethal action so severe as to prevent nuclear division in the ascus altogether.

The contents of the ascus degenerate but the wall begins to thicken and darken in color along branched lines so that eventually it has the same kind of striation and coloration shown by normal ascospores as they ripen, and cross sections of mature aborted asci show that the olive brown substance is deposited in just the same way (TEXT FIG. 1). About seventeen cog-like thickenings can be seen in median cross sections of ascospores of *N. tetrasperma*, whereas cross sections of aborted asci may show as many as 50 thickenings (TEXT FIG. 1). Furthermore this brittle chitinous substance is present down to the very lower end of the ascus. There are often a number of hard dark-brown spherical bodies in an aborted ascus (PLATE 42, A–C). Their nature is not clear. They are certainly not spore remnants.

Perithecia containing aborted asci often show spore abortion also. Some asci may have four good spores, but there is usually much irregularity as to their number, size and shape. As noted previously there is a greater tendency to form asci containing more than four spores than is normal for this species. Eight-spored asci are fairly common, but in non-lethal perithecia such asci are very rare. One may have to examine a thousand or more perithecia before finding one. Harper (1905) showed very clearly that in certain powdery mildews some nuclei become attached to the ascus wall and die, while the remaining nuclei delimit spores. The fact that we have in the species of *Neurospora* regularly four nuclear divisions may have some bearing on the question as to whether in certain cases of ascus abortion some of the eight nuclei may not succeed in cutting out spores while the others die. Spore abortion is very well known in many groups of Ascomycetes but cases where the ascus "aborts" but still continues to develop to become a differentiated indurated structure so that it resembles

a giant spore, have not been reported elsewhere so far as has come to the writer's attention. Zickler who treated *Sordaria macrospora* and *Neurospora crassa* with chloral hydrate obtained structures resembling our aborted indurated asci, but he did not recognize them as such.

Wodehouse (1929) has reported that in a certain variety of *Cichorium Intybus,* he finds something analogous to these indurated

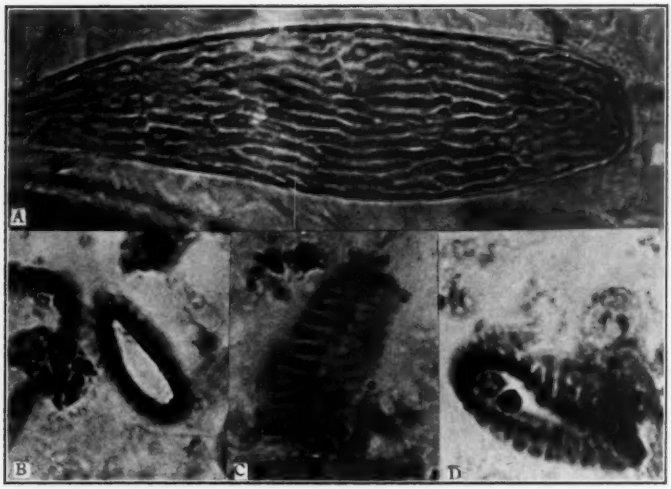

FIG. 1. A, "Aborted ascus" of *Neurospora tetrasperma,* one parent derived from an x-rayed ascospore. Such asci have thick olivaceous to dark-brown, brittle, striated walls resembling giant ascospores; B–D, Thickenings and contents as they appear in sections.

asci. He says: "For example, in the variety known as 'Red-leaved Treviso,' a large proportion of the pollen mother cells do not divide; in these the material of the special mother-cell walls is deposited in a granular concretion on the surface, but such cells appear to be deficient in power to properly organize it. . . ." "Yet, at least in some cases, spines are weakly developed, and they and the texture of the exine bear an unmistakable resemblance to those of the normal grains. The symmetrical triradiate pattern is a haptotypic character and, lacking the contact stimuli, fails to develop, but the spines and texture are emphytic and develop, at

least in part, independently of contact stimuli. These formless giants call to mind the giant spores and 'indurated asci' recently described by Dodge (1928) among the progeny of his hybrid *Neurosporas. . . .*"

In discussing this subject again with Doctor Wodehouse recently, he offered to reexamine his preparations with the view of sketching one of the abnormal pollen mother cells. The following is a quotation from his letter transmitting the sketch which is reproduced as figure 2 in the text.

"In the longitudinal sections of the buds, which were fixed just

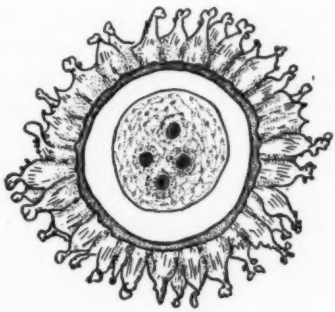

FIG. 2. "Aborted pollen mother cell" of *Cichorium Intybus* sketched by Dr. R. P. Wodehouse. Shows spine-like thickenings of mother cell wall similar to those characteristic of pollen grains. The four aborting nuclei still present. Shrinkage of the mother-cell cytoplasm due to poor fixation.

after the pollen grains reached maturity, it was found that some of the loculi contained normal pollen while adjacent loculi contained grains still united in tetrads, joined together by pit connections but otherwise almost perfectly developed, and still other loculi contained undivided pollen mother cells, apparently with one, two, three or four nuclei. In other words, in a single flower occur pollen mother cells arrested in all stages of division, from no division at all—not even the nucleus—to complete separation of the four daughter cells. But all of these, regardless of the stage of their development at the time of its arrest, received their full share of the secondary thickening material of the exine. In those grains which had succeeded in separating, this material was

properly organized, forming the normal pattern for chicory pollen which is made up of a system of high anastomosing ridges bearing pointed spines. In those which still remained joined by pit connections the pattern was more or less perfectly formed, though variously irregular. But in the undivided giants there was scarcely any suggestion of the pattern. The spines were generally more or less perfectly formed, though variously irregular in size and shape" (TEXT FIG. 2).

The markings on pollen grains are now said to be maternal in origin and inheritance. Perhaps we have in the aborted indurated asci of *Neurospora* evidence bearing on the nature of ascospore markings. No one has adequately explained how the striations to be found on the ascospores of *Ascobolus,* for example, are developed. Certainly in *Neurospora* the markings on the ascospores and those of the "aborted" ascus wall are laid down outside of the protoplast but within the outermost layer of the original wall in each case.

ABORTED INDURATED ASCUS DUE TO OTHER CAUSES

We may now consider the four dried cultures of October 26, 1929, previously mentioned as containing perithecia with many aborted indurated asci (PLATE 42, C). Those perithecia also produced some ascospores. The question arises, would cultures obtained from the ascospores have in turn produced perithecia with indurated asci and have shown a Mendelian inheritance of a lethal factor in the same way as that manifested by the progeny of the x-rayed ascospore G_5–3? To be able to answer this question five years after the cultures had dried out depended on whether the spores would still germinate.

On November 11, 1930, or about one year after the cultures had dried out, melted corn meal agar was poured into the tubes to revive the cultures. The old agar on drying had split away from the glass and curled up so that the new agar hardened below the original slant. It was easy on March 20, 1934, to separate the two slants in a tube. The perithecia that had formed on the 1930 medium contained no aborted asci, indicating that the mycelium that grew out from the revived 1929 culture was normal, just as were the mycelia that had been transferred to the tubes originally

from tester strains S_1 and S_8. Perithecia from the older slant of 1929 contained many of the deeply colored aborted asci as well as some good ascospores. Ascospores from the 1930 perithecia were given the heat treatment. They germinated abundantly as the result. Forty-four single spore cultures all produced normal perithecia and, as was to be expected, not a single aborted indurated ascus could be found in them.

Eleven perithecia containing large numbers of the brown aborted asci were then taken from the 1929 part of the culture and 148 single ascospore cultures were obtained from spores judged by their size to be bisexual. Of these 70 produced perithecia, 46 made normal growth, but when grown alone remained sterile. Thirty-two either died soon after germinating or developed very much dwarfed mycelia. A few of the fertile cultures showed much spore abortion and some evident ascus abortion but none produced the typical dark-colored aborted indurated asci.

That some lethal factor is at work to reduce the viability of the germ tubes and to inactivate the nuclei of one sex frequently is evident from the number of spores that died as soon as they had germinated or after they had developed a dwarfed mycelium, and from the number of cultures that reacted as unisexual races when they should have been bisexual.

Aborted indurated asci induced by chloral-hydrate

Zickler (1931) working with *Sordaria macrospora* and *Neurospora crassa,* treated his cultures for various periods of time with chloral-hydrate. He was able in this way to obtain numbers of giant ascospores. His figures Abt. 5 and 6, which are from photomicrographs show in addition to true giant ascospores, aborted indurated asci. In case of *N. crassa* no striations show in his reproductions but the asci are black down to the very end. He refers to these structures as giant ascospores which completely fill the ascus, lying close to the wall all around and extending down to the very bottom, taking the exact form of the ascus. If he had tried to germinate these structures or had made cytological preparations he would no doubt have found that these structures were not giant ascospores at all but really aborted indurated asci such

as the writer had figured previously (1928) and the same as are shown in our plate 42. He germinated several of the true giant ascospores but he does not report concerning progeny ascocarps nor did he claim he had affected a genotypic change.

The effect of chloral-hydrate evidently was similar to that of the unknown agent responsible for ascus abortion in our cultures of 1929, where the stimulus or destructive agent must have been active sometime during the life of the culture, so that some asci would abort while others would not be affected.

CONCLUSIONS

It is not the purpose of this paper to enter into a discussion from a genetic standpoint of the mechanism responsible for ascus abortion in the x-rayed line. Since 50% of the uninucleate f_1, f_2, or f_3, ascospores die after growing slightly, one might hazard a guess that ascus abortion is due to a typical induced deficiency comparable to that recently described by Stadler (1934) in his paper on haplo-viable deficiency in maize. Here the aborted pollen dies after the two nuclear divisions. Rarely the pollen tube emerges slightly. The deficiency is never transmitted through the male gametophyte. It is sometimes transmitted through the female gametophyte but with reduced vitality. In *Neurospora* male and female gametophytes are not differentiated as such, but they are of the plus and minus order. The deficiency, if we may call it that for convenience, is rarely, if ever, carried through a gametophyte arising from a uninucleate spore. Should a similar deficiency be induced in *N. sitophila* it would be fatal, but in *N. tetrasperma* where the ascospore will contain a normal as well as a deficient nucleus and the two nuclei divide at about the same rate, the transmission of the deficiency through the bisexual gametophyte is assured.

One can perpetuate the deficiency vegetatively if the cultures are stored at a temperature low enough to prevent the formation of ascocarps. Since the ascospores remain viable for several years one ought to obtain fresh cultures which will mature aborted indurated asci at any time by germinating the spores.

SUMMARY

A culture, G_5–3, of *Neurospora tetrasperma* derived from a bisexual x-rayed ascospore is practically self-sterile, but it reacts sexually as sex A with tester strain S_1. The resulting ascocarps contain numbers of dark-colored aborted indurated asci with no spores, as well as some asci that mature ascospores.

Cultures obtained from bisexual f_1, f_2, f_3 and f_4 ascospores produce perithecia which in turn contain the dark-colored empty asci. The lethal for ascus abortion is segregated at meiosis so that each bisexual ascospore contains at its origin one normal and one deficient nucleus, that is, one containing the lethal agent, whatever it may be. The lethal for aborted ascus is, therefore, carried on from generation to generation only through those ascospores containing two nuclei of opposite sex at their origin. The small uninucleate, and therefore unisexual ascospores are of two sorts. Some die soon after they germinate. These carry the lethal. Others being normal produce mycelia of normal growth. Of the latter, two of opposite sex, when mated together, produce normal perithecia with no aborted indurated asci whatever.

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EXPLANATION OF PLATES

PLATE 42. *Neurospora tetrasperma*

A. Aborted asci from mating (G_s–3) × S_1. The race G_s–3 derived from an x-rayed ascospore. S_1 is a normal tester sex B race.

The lethal does not always prevent ascospore delimitation but the bisexual ascospore cut out will carry the lethal in one of its nuclei. The other nucleus will be normal.

B. Aborted asci from second generation f_2 ascospores. Note one ascus has eight spores, four larger and more mature. These would be normal unisexual spores; their mycelia when mated would give rise to normal perithecia with asci like those shown in plate 43, B. The other four spores would die even if they germinated.

C. Aborted asci from non-irradiated line, October 26, 1929. Here the ascospores, still viable in 1934, do not carry the lethal, because the agent responsible for ascus abortion was active only during ascocarp formation. The mycelium in the culture was normal, and only a certain number of asci in a fruit body were affected.

PLATE 43. *Neurospora tetrasperma*

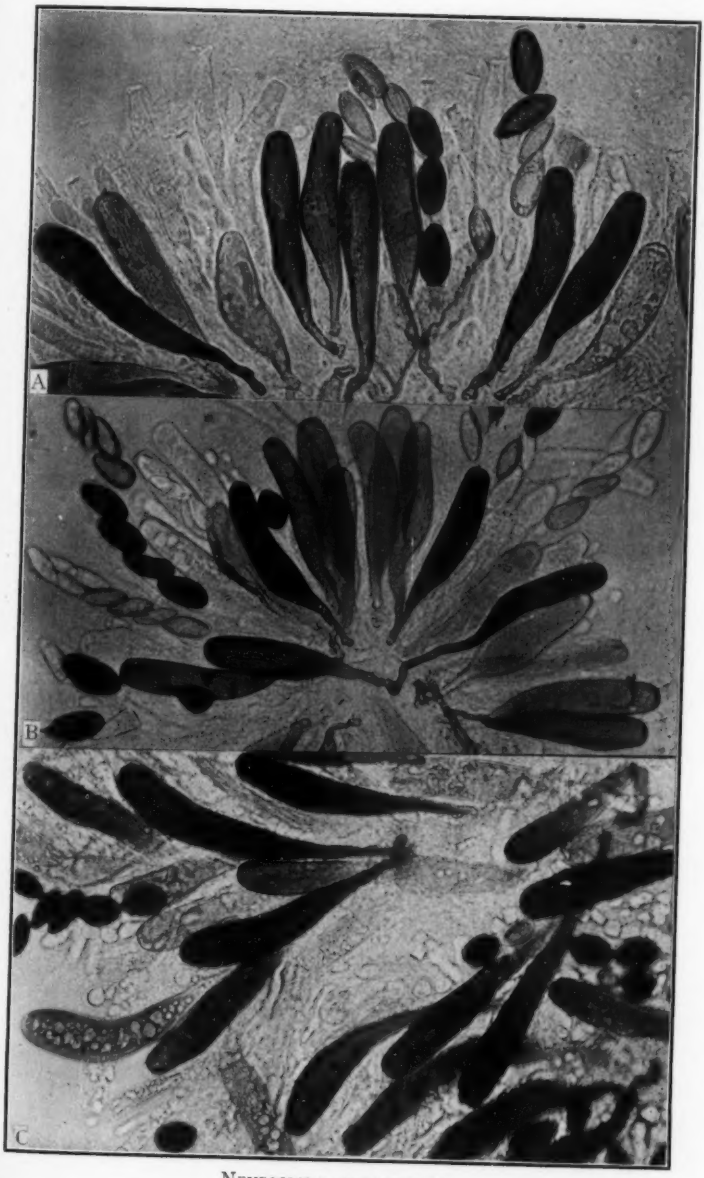
A. Aborted asci from a line of hybrid origin. From a preparation of material obtained in 1927.

B. Normal asci from perithecium obtained by mating mycelia derived from the small unisexual spores which are not uncommon in the irradiated line.

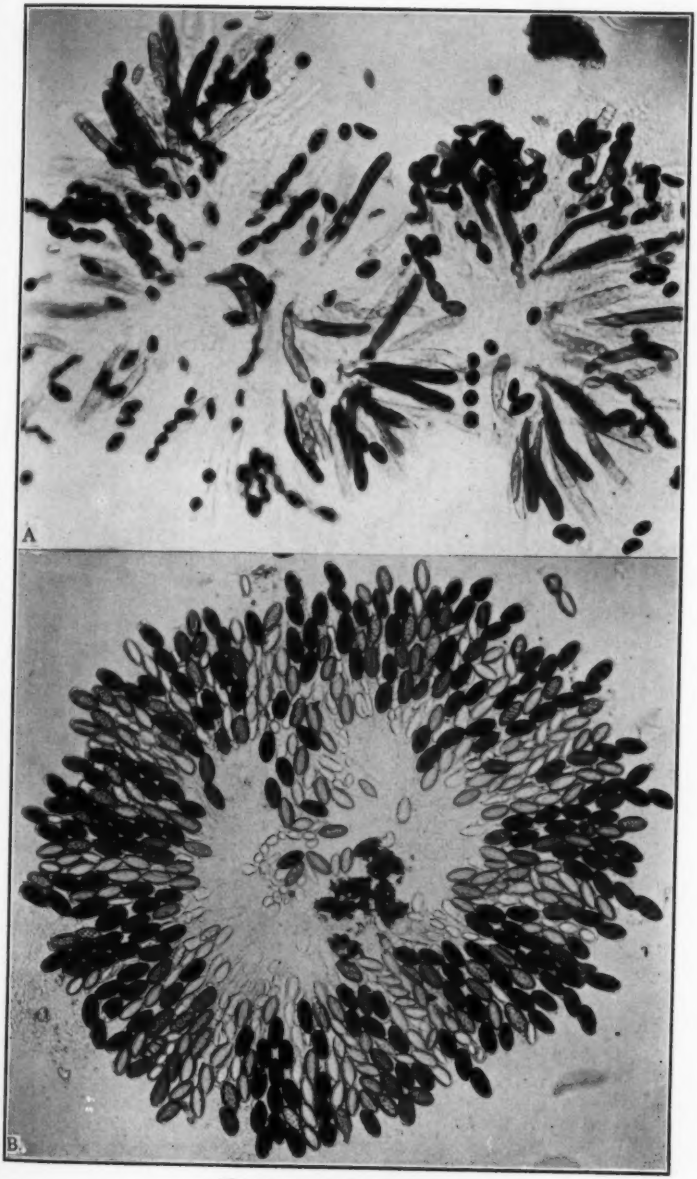
Unisexual ascospores whose nuclei carry the lethal factors die soon after germination. "Aborted ascus" can be perpetuated through the larger spores which carry one normal and one lethal nucleus, but not through unisexual spores.

PLATE 44

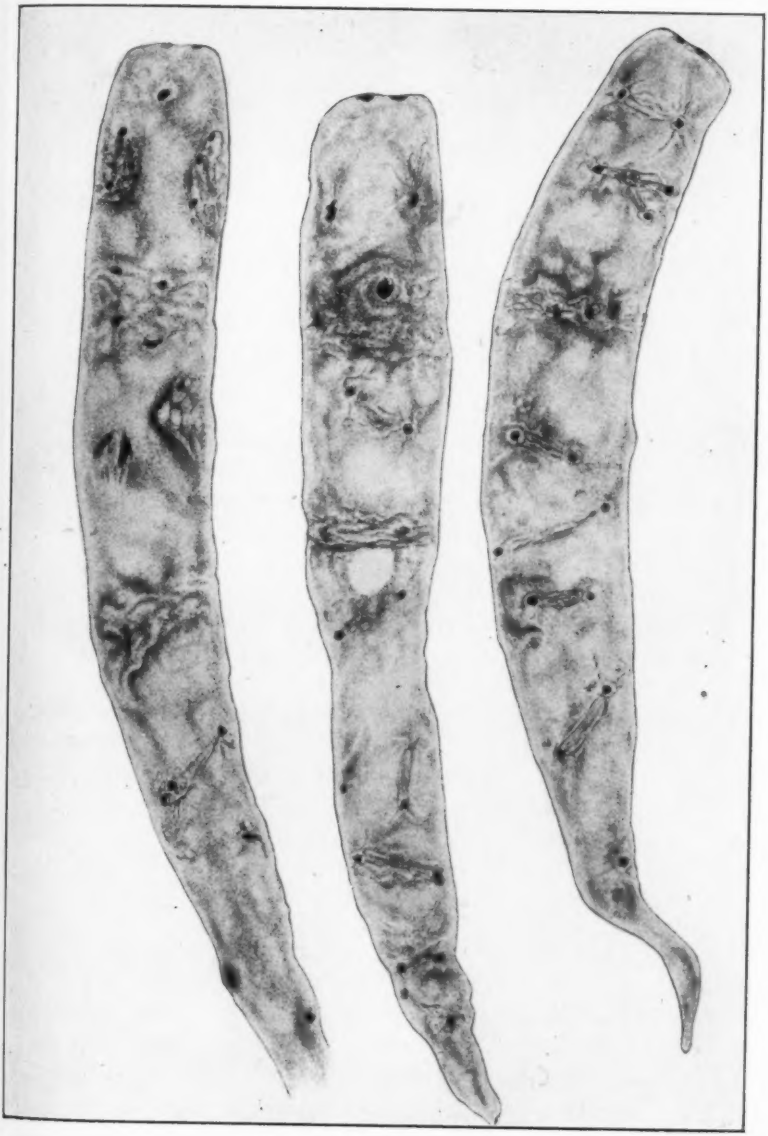
Longitudinal sections of aborted asci; each of the two at the right shows seven or eight pairs of nuclei still connected by spindle fibres. The nuclei become attached to the ascus wall and die. These asci would not have formed spores.



NEUROSPORA TETRASPERMA



NEUROSPORA TETRASPERMA



NEUROSPORA TETRASPERMA

NOTES AND BRIEF ARTICLES

Notice to Subscribers

Beginning January 1, 1935, the subscription price of MYCOLOGIA will be increased to six dollars ($6.00) per year. With this increased price it is expected that a minimum of 600 pages will be printed per year. This action will not affect members of the Mycological Society of America who will continue to receive MYCOLOGIA under the terms of the contract as formerly.

Recently, in a paper [1] containing diagnoses of a number of new chytridiaceous fungi, I applied the generic name *Scherffelia* n. gen. to a form possessing a peculiar method of development. It has come to my attention that there exists a small genus of algae belonging to the Volvocales to which this generic name has already been applied.[2] In order that Dr. Scherffel's name shall continue to be associated with this group of fungi to our knowledge of which he has contributed so many valuable observations it will be necessary to emend my first appellation of this fungus.

The following new generic name is therefore proposed for it.

Scherffeliomyces gen. nov.

Syn. *Scherffelia* Sparrow, Trans. Brit. Myc. Soc. **18** (3): 216. 1933. non *Scherffelia* Pascher, Hedwigia **52**: 281. 1912.

F. K. SPARROW, JR.
DARTMOUTH COLLEGE,
HANOVER, N. H.

THE SEVENTH LAKE FORAY

In the previous number of MYCOLOGIA, pages 277–278, announcement was made that the summer foray of the Mycological Society will be held at Seventh Lake, near Inlet, N. Y., August

[1] Trans. Brit. Myc. Soc. **18** (3): 216. 1933.
[2] Hedwigia **52**: 281. 1912.

21–24, with headquarters at Stewart's Camp. *Mycologists expecting to attend the foray, and who have not yet made arrangements for living accommodations,* should communicate at once with Professor F. C. Stewart. Until August 10 his address will be Agricultural Experiment Station, Geneva, N. Y.; after August 10, Inlet, N. Y.

Arrangements are being made to provide lunch and dinner at Stewart's Camp thereby enabling the visiting mycologists to be together the greater part of each day. Lodging and breakfast will be provided elsewhere at three different places. Launches will take parties to Stewart's Camp each morning and return them to the lodging places in the evening. The rates, including lodging, meals, and launch service, will vary from $3 to $4 per day according to the accommodations.

Mail should be addressed in care of Stewart's Camp, Inlet, N. Y.; telegrams to Stewart's Camp on Seventh Lake, care of A. W. Every, Old Forge, N. Y. Telegraphic service is poor and expensive. *Whether arriving by train or by automobile guests should proceed at once to Every's boat landing on Seventh Lake, two miles east of Inlet, where full information may be obtained.* Motor-busses, meeting all trains at Thendara, will discharge passengers at Dad's Inn three-tenths of a mile from Every's boat landing. Motor-busses run, also, between Utica and Dad's Inn, a distance of 67 miles. Those desiring taxi service from Dad's Inn to Every's should notify A. W. Every, Inlet, N. Y., stating time of arrival.

B. O. DODGE, F. C. STEWART AND H. M. FITZPATRICK,
Committee on Arrangements

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